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THE IRRAWADDY RIVER

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IN addition to numerous incidental references, the Irrawaddy river has been the subject of two special communications to this Society. In 1879 Robert Gordon, who had been for many years in charge of river works in Burma, prepared an official report[1] in which he stressed his belief in the identity of the Tsangpo of Tibet and the Irrawaddy. In reply Major J. E. Sandeman marshalled the facts for the opposite view in a paper read before the Society.[2] Gordon replied in a letter from Burma[3] and later prepared an important paper on the river as a whole.[4] In the first part of this paper he gives details of the results of ten years of careful river gauging and many of the estimates Gordon then published have never been superseded. Unfortunately the second part of the paper is devoted to a long defence of his previous views (accompanied by a hypothetical map) which by that date had few adherents. The long controversy was not settled till much later by the work of the Survey of India, particularly of Bailey and Morshead, in proving the identity of the Tsangpo and Brahmaputra.

Since the annexation of Upper Burma in 1886 detailed survey work has been steadily pushed forward, but there are still huge areas unmapped geologically and accordingly many unsolved problems relative to the geographical evolution of the river in the far north. The broad relationship between the structure and the physiography of the north-eastern corner of Burma and the neighbouring parts of Yunnan was one of the problems which the late J. W. Gregory hoped to solve in the Percy Sladen Memorial Expedition of 1922,[5]

[1] R. Gordon, C.E., 'Report on the Irawadi river.' Rangoon, 1879–80.

[2] J. E. Sandeman, "The river Irrawadi and its sources." *Proceedings R.G.S.* N.S. 4 (1882) 257–73.

[3] *Ibid.*, pp. 559–63.

[4] R. Gordon, "The Irawadi river." *Ibid.* 7 (1885) 229–31.

[5] J. W. and J. C. Gregory, "The Alps of Chinese Tibet and their geographical relations." *Geogr. J.* 61 (1923) 153–79.

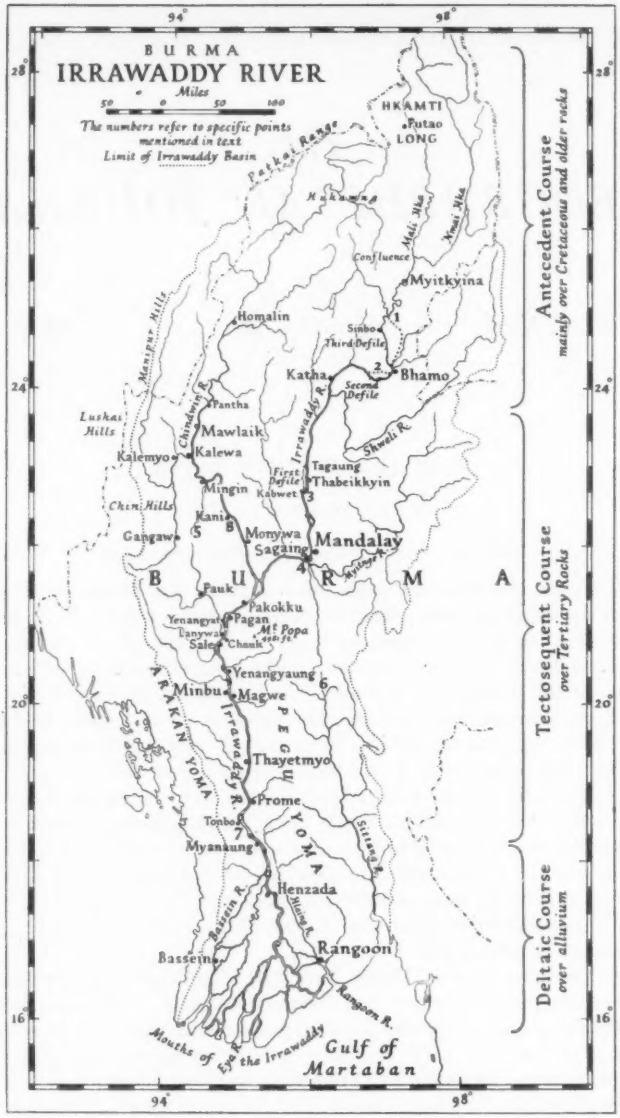


Fig. 1

1 and 2. Abandoned course of the Upper Irrawaddy; 3. Sudden change of course caused by the Quaternary or recent lava platform opposite Kabwet; 4. The Ava bridge; 5. E.-W. axis of uplift or warping in lat. 22° N.; 6. Possible E.-W. axis of uplift separating the headwaters of the Sittang from the Irrawaddy; 7. Position of the Akauktaung cliffs; a few miles below, on the opposite bank, is Tarokmaw; 8. Crater lakes and lava flows, with ash beds, constricting the course of the Chindwin

and his report, combined with the results of Coggin Brown's work in Yunnan, marks an important advance in factual knowledge and interpretation. In the last few years traverses made by officers of the Burma Party of the Geological Survey of India and the gradual extension northwards of their regular surveys have thrown a flood of light on the story of the geographical evolution of the country.

It is the purpose of the present paper to put on record the results of a series of gaugings carried out over the past thirty years by the Irrawaddy Flotilla Company, and so to publish for the first time certain details of the river regime, to record also the results of a series of field observations, particularly on the Chindwin, and to review the present state of knowledge.

The field observations were begun in the cold weather of 1921–22 when it was my duty, in the course of a search for oil, to carry out a reconnaissance geological survey of some 500 square miles in the Lower and Upper Chindwin districts.[1] The survey was necessarily based on traverses along the many magnificent gorges of the youthful tributaries of the Chindwin, at that season practically dry. In the following year, 1922–23, my work was mainly along the lower Irrawaddy.[2] In 1923, after my appointment as first Professor of Geology and Geography in the University of Rangoon, opportunities occurred of examining the upper reaches of the Irrawaddy and especially of changes in its course occasioned by recent lava flows.[3] The hot weather of 1924 was spent in the detailed investigation of a huge sandbank which has since been embanked to become the very successful oilfield of Lanywa.[4] Before my return to England in 1926 I was also enabled to make a series of studies in the delta,[5] but no attempt has been made so far to publish the results of these various observations on the river since previous papers have dealt with geology or economic geography.[6] In the early part of 1938, after the Jubilee meeting of the Indian Science Congress, the long-awaited opportunity came of revisiting Burma, this time as a leisured visitor. I seized the chance of returning to old haunts along the Chindwin, of studying the new Ava bridge below Mandalay, and of noting changes at many points after a lapse of twelve years. Mr. A. T. McCreath, General Manager of the Irrawaddy Flotilla Company, very generously allowed me access to the confidential records of the company dealing with river gauging in its relation to navigation, and I was afforded the opportunity of discussing the river regime with several of the company's experienced captains and pilots. I should like particularly to thank Captain R. A. P. Spears who, in the course of twelve days spent on the *Sima* up and down the Chindwin proved not only a charming host but provided a fund of valuable information on the river. The greater part of a day spent stuck on a sandbank afforded also some important object lessons.

[1] L. D. Stamp, "The geology of part of the Pondaung Range, Burma." *Trans. Min. geol. Inst. India* 17 (1922) 161–80.

[2] L. D. Stamp, *Geol. Mag. Lond.*, 62 (1925) 515–28; *J. Burma Res. Soc.* 17 (1927) 177–89.

[3] L. D. Stamp, and H. L. Chhibber, "The igneous and associated rocks of the Kabwet area." *Trans. Min. geol. Inst. India* 21 (1927) 97–128.

[4] L. D. Stamp, "The oil fields of Burma." *J. Instn. Petrol. Tech.* 15 (1929) 300–45.

[5] L. D. Stamp, *J. Ecol.* 13 (1925) 262–76.

[6] *Vide inter alia Geogr. Rev.* 15 (1930) 80–109.

The Irrawaddy is a river of particular interest for several reasons. It is unique amongst the rivers of south-eastern Asia in that its basin lies almost wholly within one country, the country of Burma, and wholly within the region of the monsoon climate. In the latter respect it differs from the great rivers of northern India which rise beyond the Himalaya and whose regime is dominated partly by monsoon rainfall and partly by Himalayan snowfall. The regime of the Irrawaddy is only affected to a very limited extent by snowfall. Further, the Irrawaddy has grown up *pari passu* with the country which it now drains. In one sense it is antecedent in that it antedates the main structural features of the country; in another sense it is consequent (in the same way as the lower Thames is sometimes claimed as consequent) in that it, and particularly its great tributary the Chindwin, tend to follow a succession of gigantic strike valleys. At the same time the post-Tertiary history of the river, with the several remarkable terraces and many striking recent changes in course and some remarkable examples of capture, is a fascinating study as yet scarcely undertaken.

The geographical evolution of Burma

The widespread occurrence of oil in the Tertiary rocks of Burma, the richness of its eastern massif in metallic minerals and precious stones, the fame of the jade and amber from the far north, have led to long-continued and close investigation of certain aspects of the country's geology both by officers of the Geological Survey of India and also by geologists employed by private interests. The work of the former is, in due course, published or at least available for consultation; the work of the latter has too often been a secret closely guarded, with the result that many areas have been independently surveyed several times. Whilst many matters are still in dispute, there is now general agreement on the main events in the geographical evolution of the country.

The eastern part of the country—broadly the Shan States—is occupied by a lofty plateau (averaging 3000 feet in height) from the surface of which rise numerous ridges. These are usually strike ridges, and in general the grain of the country is markedly from north to south. The whole consists of rocks ranging in age from pre-Cambrian to early Cretaceous with granites and intrusive gneisses probably of the latter age. The whole appears to have been folded in Cretaceous times as the Indo-Malayan mountain system.

On the west Burma is separated from India by a complex anticlinorial fold of Alpine–Himalayan age, extending southwards as the Arakan Yoma range of mountains. Whilst Pliocene rocks on the flanks are involved in the folding, there is a crystalline core of unknown age but probably including rocks from pre-Cambrian to Cretaceous, and the folding appears to have been initiated in Cretaceous times.

The central basin of Burma, between these two units, consists in the main of gently folded tertiary strata with volcanic manifestations locally. This is the basin of the Chindwin, the Lower Irrawaddy, and Sittang rivers.

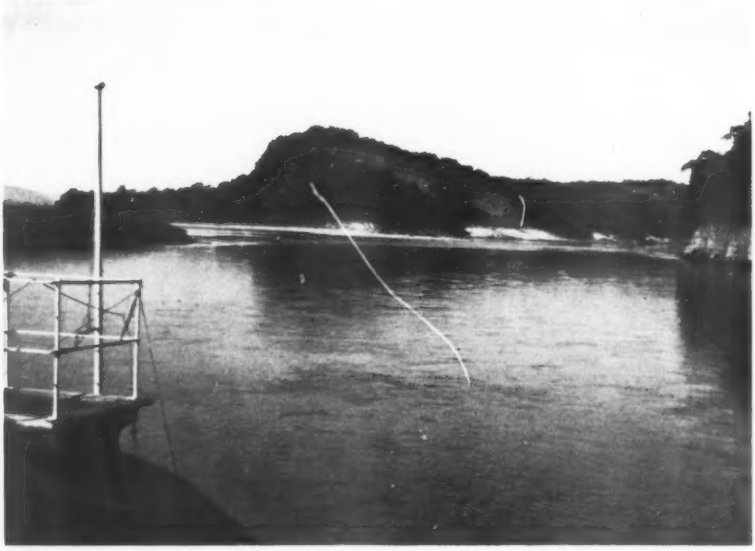
The general history of Burma in Tertiary times was sketched by Dr. G. de P. Cotter.[1] His general thesis has been confirmed and elaborated by

[1] G. de P. Cotter, "The geotectonics of the Tertiary Irrawaddy basin." *J. Asiat. Soc. Beng.* N.S. 14 (1918) 409–20.

The Ava bridge across the Irrawaddy at low water in February

The Ava bridge during a monsoon flood in August

A section of a strike course of the Chindwin, looking south



The Chindwin cutting through the sandstone ridge to the right from one strike valley to another

later writers, including myself[1] and G. W. Lepper.[2] Lepper's confirmation is especially important in that it is based on the immense amount of detailed field work carried out over a long period by the geologists of the Burmah Oil Company. Recently important modifications of the original ideas have been made by E. L. G. Clegg[3] as a result of his investigations on limestones bordering the Upper Irrawaddy, previously thought to be pre-Cambrian and now shown to contain Cretaceous fossils.

At the beginning of Tertiary times it would seem that Burma was occupied by a marine gulf bounded on the east by the then newly folded Indo-Malayan mountains and cut off from the Assam Gulf on the north-west by the incipient ridge of the Arakan Yoma. Into this gulf there poured from the north, from central Asia, one or more great rivers, and the history of the Tertiary period in Burma is essentially the history of the infilling of this gulf—with river-borne sediments from the north and sides and marine sediments in the south. The gulf is better described as a twin-gulf with a longitudinal central ridge and the deposits laid down in the two halves differ considerably, whilst intra-formational unconformities, old volcanoes, and volcanic deposits are associated with the central ridge (*e.g.* Mount Popa).

In parts of the western basin the Tertiary deposits reach an enormous thickness—certainly exceeding 60,000 feet. The sequence is:

Irrawaddian or Irrawaddy Series (Mio-Pliocene), mainly freshwater sands.

Peguan or Pegu Series (Oligo-Miocene), alternating clays, shales, and sandstone, mainly marine

Eocene or Nummulitic, mainly marine sandstones and shales.

On the whole there is a gradual change, as one would expect, from predominantly continental deposits in the north to mainly marine in the south, and many marine beds in the south give place to estuarine and fluviatile deposits when traced northwards. The gradual infilling from the north and the pushing of continental deposits southwards was interrupted at intervals by a buckling of the floor of the gulf, with the consequent temporary return northwards of marine conditions in the troughs so formed and the development of intra-formational unconformities which are most marked when beds are traced to west or east.

In the eastern half of the gulf, that is east of the main crest of the Pegu Yoma and Mount Popa, the representatives of the higher Peguan are more sandy and no older beds have yet been discovered. Accordingly Clegg believes that this eastern half of the gulf remained land until late Peguan times and provided much of the sediment for the beds of the western gulf. All the oil of Burma occurs in the western gulf; there is some oil in the Eocene rocks, but

[1] L. D. Stamp, "An outline of the Tertiary geology of Burma." *Geol. Mag. Lond.* 59 (1922) 481–501; "The geology of the oil fields of Burma." *Bull. Amer. Ass. Petrol. Geol.* 11 (1927) 557–69.

[2] G. W. Lepper, "An outline of the geology of the oilbearing regions of the Chindwin–Irrawaddy valley of Burma, and of Assam–Arakan." *World Petroleum Congress*, 1933.

[3] E. L. G. Clegg in A. M. Heron, *Rec. geol. Surv. India* 77 (1937) 63; also *Mem. geol. Surv. India* 72 (1938) 170.

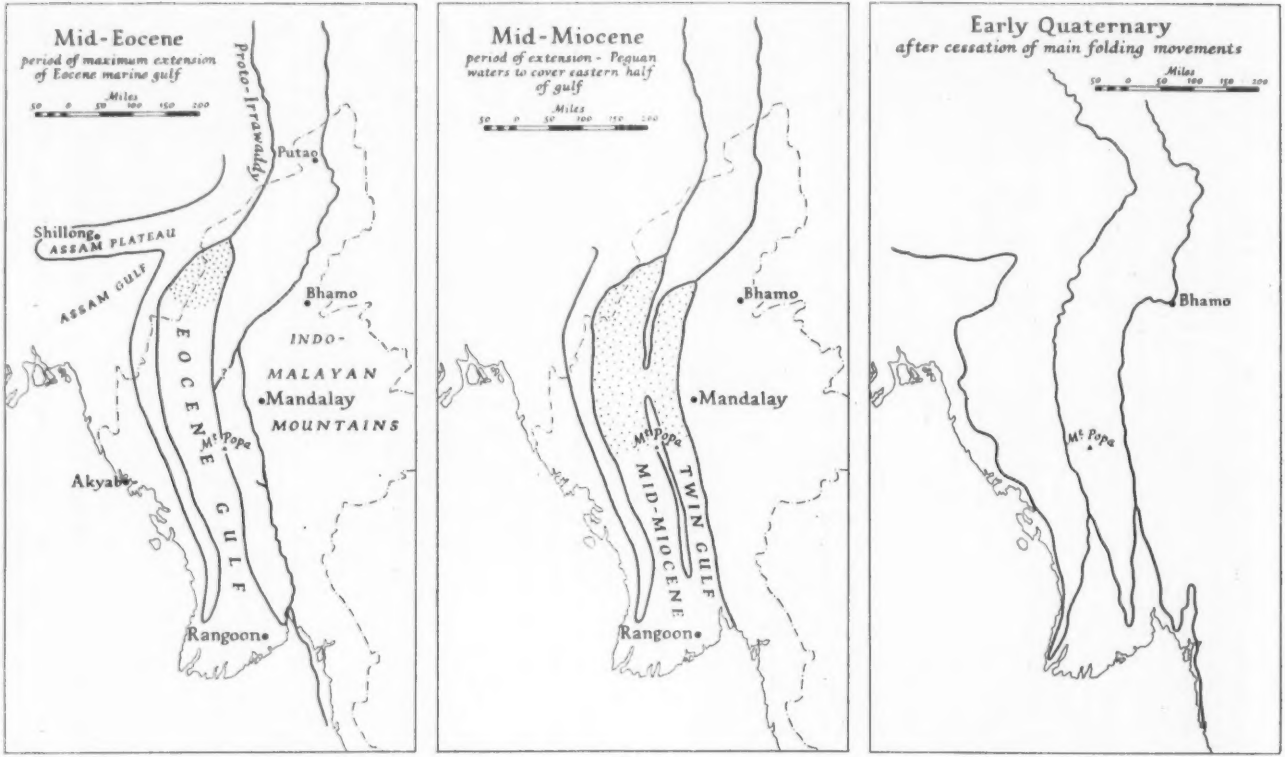

Mid-Eocene
period of maximum extension of Eocene marine gulf
Miles
50 0 50 100 150 200
Proto-Irrawaddy
Putao
Shillong
ASSAM PLATEAU
ASSAM GULF
Bhamo
INDO-
MALAYAN
MOUNTAINS
Mandalay
Mt. Popa
EOCENE GULF
Akyab
Rangoon
Mid-Miocene
period of extension - Pegu waters to cover eastern half of gulf
Miles
50 0 50 100 150 200
Bhamo
Mandalay
Mt. Popa
MID-MIOCENE
TWIN GULF
Rangoon
Early Quaternary
after cessation of main folding movements
Miles
50 0 50 100 150 200
Bhamo
Mt. Popa

Fig. 2

the bulk is obtained from those Peguan rocks which were deposited under brackish water or shallow-marine waters. The heart of Burma, with its centre near Yenangyaung, is a broad shallow syncline and the oilfields (with only one important exception) are associated with anticlinal ridges in the midst of this syncline. Farther south, where the folds from the Arakan Yoma approach closely to those from the Pegu Yoma and where the Peguan gulf may have been constricted, there is no oil.[1]

It would thus seem that the great Tertiary river, which may be called the Proto-Irrawaddy, flowed into the gulf roughly along the line of the present Chindwin and later extended southwards, as the gulf became infilled, along the present course of the Lower Irrawaddy. There was probably a parallel river along the line of the Upper Irrawaddy and Sittang, which may be called the Proto-Sittang.

The Proto-Irrawaddy (or Chindwin–Lower Irrawaddy) was thus in existence as the consequent median stream of a major synclinal trough before the advent of the folding movements which have rucked that synclinal trough into a succession of north–south ridges. So the river and its tributaries were gradually pushed into their present positions by tectonic upheavals. Thus the alignment of the rivers is clearly resultant upon geological structure; their courses for the most part follow the original synclinal hollows or at least strike valleys excavated in the less resistant shales. As Cotter has pointed out, when crossing the lines of anticlinal folds, the courses choose the saddles or skirt the terminations.[2] A specific case, in the Chindwin area below Kalewa, is analysed in detail below.

It would thus seem that many, if not most, of the major features in the courses of the Chindwin and Lower Irrawaddy were determined prior to the close of the Pliocene. The rivers were then, naturally, at a higher level, and probably had headwaters in central Asia since captured by the Brahmaputra. The history of post-Pliocene times seems to have been marked by (*a*) a virtual cessation of major folding movements; (*b*) a substitution of certain regional uplifts which have caused successive rejuvenation and the development of a series of terraces; (*c*) warping which has resulted in certain major changes of course—notably the separation of the Upper Irrawaddy from the Sittang and the throwing of the water of the former into the Lower Irrawaddy; and (*d*) volcanic activity which has resulted in some minor changes of course.

The terraces or peneplaned surfaces have long attracted attention because of their wide extent, extreme flatness, and their deposits of bright red ferruginous quartz gravels,[3] but have only recently been the subject of more than

[1] In a personal communication since this paper was read, Dr. Cotter summarizes the position thus: "My idea is that the Arakan sial mass has been steadily approaching the Shan plateau since the beginning of the Tertiary, that the whole area was an open concertina in early Tertiary, that the Eocene gulf lay westward and only on its eastern flank coincident with the Pegu gulf, that the Sittang gulf was mainly subsequent to the Pegu, for much of the Sittang deposits are of the passage-bed type, an age when the Red Bed [at the top of the Peguan] indicates land over the western gulf."

[2] G. de P. Cotter, "The geology of parts of the Minbu, Myingyan, Pakokku, and Lower Chindwin districts, Burma." *Mem. geol. Surv. India* 72 (1938) 17.

[3] E. H. Pascoe, "The oilfields of Burma." *Mem. geol. Surv. India* 40 (1912).

a general study so that, despite the work of Morris and de Terra,[1] much remains to be done.

The course of the Irrawaddy

The course of the Irrawaddy is now so well known and, at least in the navigable course from Bhamo to the sea, so familiar to travellers that it is only necessary here to recall the main features.

(*a*) *Above the confluence.*—A number of mountain torrents, rising along the northern border of Burma (where snow-capped mountains rise to over 15,000 feet and there are several large glaciers) unite at the foot of the hills to form two considerable streams, the Mali Hka and 'Nmai Hka, the western and eastern branches of the Irrawaddy which join at the confluence to form the main river. The 'Nmai and its tributaries are wild mountain streams ('Nmai Hka=Bad Waters), but the Mali, though carrying less water, has the appearance of a comparatively mature stream (Mali Hka=Big River, a reference to navigability). A few dozen miles from the sources of its head streams the Mali is already a river flowing quietly across the Hkamti-Long valley and then for some 200 miles through a deep valley.[2] Although interrupted by rapids, considerable stretches are navigable and the conclusion is inevitable that this valley represents part of the valley of the Proto-Sittang, cut off from the original Tibetan course of the river by tectonic uplifts following the trend of the Himalaya. The Irrawaddy differs from the Brahmaputra, the Salween, Mekong, and Yangtze, in having failed to keep pace in down-cutting with the tectonic uplift. It is immediately to the north-east of Burma that the three last-mentioned rivers flow in great parallel gorges which suggest, on the physical map, strike valleys. On the other hand theoretical considerations suggested that the general strike should here be east–west,[3] and it was to settle this important question that the Percy Sladen Memorial Expedition, led by J. W. Gregory, carried out traverses in 1922.[4]

It is now generally agreed that the Mali Hka is an antecedent stream, comparable in character with the upper or Himalayan courses of the Indus and Ganges. The long straight valley of the 'Nmai Hka is also not a strike valley though it may well follow a major fracture line.

(*b*) *From the confluence to Bhamo.*—A short distance below the confluence stands Myitkyina, railhead of the Burmese system and starting-point for the 230-mile-long track to Putao. It is 150 miles from the confluence to Bhamo, and the river is navigable throughout. Though there is no regular passenger

[1] H. de Terra, "The Quaternary terrace system of Southern Asia and the Age of Man." *Geogr. Rev.* 29 (1939) 101–18. T. O. Morris, "The prehistoric stone implements of Burma." *J. Burma Res. Soc.* 25 (1935) 1–39; 26 (1936) 163–5).

[2] This northern corner of Burma is country particularly associated with the explorations of Captain F. Kingdon Ward and described in many communications to the Society. The ancient peneplane with associated monadnocks, which he described under the title of "The Irrawaddy plateau" (*Geogr. J.* 94 (1939) 293–308), now at an elevation of 14,000 to 15,000 feet, may be of Oligo–Miocene age and its formation may have provided the material for the Peguan sediments.

[3] Already suggested by the traverses of Murray Stuart, *Rec. geol. Surv. India* 54 (1923) 398–411.

[4] J. W. and C. J. Gregory, *op. cit. supra;* see also 'The structure of Asia.' London, 1929.

service above Bhamo, steamers can reach the confluence except when the current through the upper defile is too strong. Just below the confluence the Irrawaddy in the low-water season is a quarter of a mile wide and has a depth in the main channel of 30 feet. Southwards it flows through hilly and then more open country and is, in places, over half a mile wide. Then suddenly, just below Sinbo, it enters the upper or third defile by a mouth only 50 yards in width. It is the swift rush of water and the consequent eddies and whirlpools which render navigation dangerous.

The course of the Upper Irrawaddy was the subject of a note in the *Journal* by Malcolm Maclaren.[1] He pointed out that east of the defile and roughly parallel to it there is a broad open valley which clearly marks a former course of the river. It is difficult to find an adequate reason for the change of course, and it is described by Maclaren as a case of "domestic piracy" caused by the cutting back of two tributaries, one flowing north and the other south, and the eventual adoption of this straight but narrow path by the main river.

The geology of the defile has only recently been studied by Clegg.[2] The defile, better described as a "narrows" with cliffs rarely exceeding 60 feet in height though flanked by mountains rising to 3000 feet, is about 40 miles long. The narrowest part is only 60–70 yards wide. The gorge as a whole is cut through crushed and cleaved grits and shales with limestone bands containing Cretaceous foraminifera and interrupted by lavas, ashes, and intrusive serpentines and diorites. It is where the intrusions have indurated the sediments that the narrowest and most dangerous sections of the defile occur, notably below the gate known as Pashaw, where there are two large whirlpools and many smaller eddies.

At Thapanbin the river emerges from the defile and immediately spreads out to meander lazily across the alluvium of the Bhamo basin.

(*c*) *Bhamo to Katha.*—At Bhamo the river swings abruptly to the west and shortly leaves the Bhamo alluvial basin to sweep through the most majestic scenery on its course, the second defile. In so doing it ignores the old alluvial-filled channel to the north and cuts instead through a limestone mass which E. L. G. Clegg has recently shown to consist of Cretaceous rocks.[3] Whilst the general east–west course is probably occasioned by the presence to the south of the main Mogok–Shan States plateau, the remarkable course of the river through the second defile in place of a course through several alternative tracts of low ground is difficult to explain. It puzzled Maclaren, it remains unexplained to-day. It is well known, of course, that deep solution channels develop in limestone and it is possible that a sub-aerial solution channel provided the necessary courseway. It is important to note that it is not a case of antecedent drainage like that of the Bristol Avon below Bristol: the existence of an abandoned channel to the north precludes that. In its narrowest part the second defile is about 100 yards wide and vertical cliffs rise in places to 200 and 300 feet. An excellent description is given by Clegg.

(*d*) *Katha to Mandalay.*—In this section the Irrawaddy assumes what may

[1] M. Maclaren, "The course of the Upper Irrawadi." *Geogr. J.* 30 (1907) 507–11.

[2] E. L. G. Clegg, in A. M. Heron, General Report *Rec. geol. Surv. India* 74, pt. I (1939) 91.

[3] *Rec. geol. Surv. India* 71 (1937) 63, 350–9.

be described as its normal tectosequent course—following a strike valley. From Katha to Tagaung the banks are mainly of alluvium, but for nearly 50 miles south of Tagaung the river follows a course which might have been drawn with a straight ruler. On the east rise steeply the crystalline hills of the Mogok section of the Shan plateau. This straight abrupt edge of the Indo-Malayan plateau massif extends, with only minor interruptions for between 400 and 500 miles, right to the Gulf of Martaban. Not infrequently the plateau edge rises 2000 or 3000 feet from the river valleys by which it is bordered on the west, and two inferences have naturally been drawn from this remarkable feature. Almost everywhere to the west are Tertiary (Irrawaddian) or later deposits, and the conclusion that this is a fault scarp is inevitable.[1] The junction however has never been adequately exposed, and amongst recent pronouncements Cotter favours an ordinary junction,[2] but Iyer a faulted one.[3] The second inference is that the Upper Irrawaddy formerly flowed parallel to this edge directly to the Gulf of Martaban. This was accepted by Gregory [4] and explains the broad misfit valley now occupied by the Sittang.

Examined in detail the river course exhibits some interesting features. Its course from Tagaung past Thabeikkyin (the river port for the Mogok ruby mines) is through the first or lower defile where the steep though rarely precipitous banks are thickly clothed with trees. These banks are of late Tertiary sandstones and the river does not depart more than a few yards from the strike. Quite suddenly, near the village of Kabwet, the river swings round a right-angled bend to the west. This is due to the interruption offered by a large sheet of lava, which seems to have been poured across the valley from a fissure coinciding closely with the Tertiary–crystalline junction. Chhibber and I pointed out that the change of course took place in historic times, that little soil has yet formed on the lava surface, and that the river now skirts the edge of the flow.[5] Southwards the river broadens out into the Mandalay alluvial basin and the Shan hills cease to exhibit a straight edge and retreat to the east with outlying hills rising as *Inselberge* from the alluvial plains. An important ridge of pre-Cambrian crystallines appears on the west bank of the river, culminating in the pagoda-studded hills of Sagaing facing Mandalay.

Round the southern end of this ridge the river swings in the most remarkable of all the changes in its course. The interruption of the main drainage and the separation of the Irrawaddy and Sittang may not be unconnected with the volcanic upheaval of Mount Popa. Intermittent volcanic activity occurred at Popa from at least early Pliocene times to a few hundred years ago,[6] and the breached crater still rises to nearly 5000 feet, or 4000 feet above the surrounding peneplane.

At the southern end of the Sagaing ridge is the Ava road and railway

[1] L. D. Stamp, *Geol. Mag. Lond.* 59 (1933) 182–5.

[2] G. de P. Cotter, *Proc. Pan-Pacif. sci. Congress, Australia*, 1924.

[3] L. A. N. Iyer, in A. M. Heron, *Rec. geol. Surv. India* 71 (1936) 61.

[4] J. W. and J. C. Gregory, *op. cit. supra.*

[5] L. D. Stamp and H. L. Chhibber, "The igneous and associated rocks of the Kabwet area." *Trans. Min. geol. Inst. India* 21 (1927) 97–128.

[6] H. L. Chhibber, "The igneous rocks of the Mount Popa region." *Trans. Min. geol. Inst. India* 21 (1927) 146–210.

bridge, opened in 1933 and the only bridge of any sort across the Irrawaddy in the whole of its 1000 miles of course.

(*e*) *Mandalay to Thayetmyo.*—From Mandalay, the old capital of Upper Burma, to Thayetmyo, the former frontier town of Lower Burma, the Irrawaddy passes through the heart of the dry belt with a rainfall ranging from 40 inches down to 20 inches—a rainfall which comes mainly in a succession of sudden storms. The dry belt of Burma consists essentially of a series of terraces or peneplaned surfaces at different elevations above sea-level and carved out of the incoherent Mio-Pliocene Irrawaddian sands. The monotony of level is interrupted by conspicuous lines of hills, of the nature of monadnocks, marking anticlinal ridges of the Oligo-Miocene Peguan series. Certain of these anticlines are of special importance owing to their association with oil, and Burma's great oilfields are in this dry belt.[1] H. de Terra[2] and T. O. Morris[3] have recently investigated the terraces in this area of Burma and the former claims to have distinguished

"five terraces, three of which are built of various gravels suggesting three major stages of aggradation. The topmost is built of bouldery red gravels, forming the oldest river drift and lies 350 feet above the present stream—an indication of a stage of lateral erosion that succeeded a period of great water supply and of laterite formation. The next younger terrace is also built of red gravel, which fills the valley to a depth of 90 feet above stream level. This is the major terrace gravel and in it were found vertebrate fossils that are characteristic of the middle Pleistocene beds of the Narbada Valley. The third gravel underlies terrace 4 and is associated with a special soil—Pagan silt—which clearly belongs to a younger stage of aggradation and wind deposition. The fifth terrace, finally, is composed of silt and clay."

In the same paper de Terra makes so many sweeping generalizations, some of which are obviously incorrect,[4] and glosses over the most disputed difficulties of stratigraphical correlation, that one is forced to suggest that much more work is needed before his various conclusions can be accepted.

It is sufficient to say that in the dry belt of Burma there exist peneplaned surfaces at various levels, usually capped with thin, coarse red (partly lateritized) gravels, as well as stretches of alluvium, sometimes also lateritized, at lower levels. The present river seems to wander irregularly across the whole: where it is bordered by the alluvial areas the banks are low and fringed with sandbanks; where it swings up against one of the terraces there are precipitous cliffs as at Pagan (about 50 feet above high-water level) or notably at Lanywa and Yenangyaung (90–100 feet above high-water level). Only when the river comes up against one of the anticlinal flexures (as at Yenangyat) is there a marked influence on its course and the main river becomes a strike stream. Even then between Singu (or Chauk) and Lanywa the river swings right across the great anticline.

[1] E. H. Pascoe, "The oilfields of Burma." *Mem. geol. Surv. India* 51 (1910). L. D. Stamp, "The oilfields of Burma." *Jour. Instn. Petrol. Tech.* 15 (1929) 300–45.

[2] H. de Terra, *op. cit. supra.*

[3] T. O. Morris, *op. cit. supra.*

[4] For example. "The Irrawaddy drains the highlands of eastern Tibet " . . . "in general, the valley marks the important geological boundary between the Himalayan belt of late-Cretaceous age and the Tertiary foredeep."

Climatic conditions in the dry belt are conducive to rapid erosion of the soft Irrawaddian sands and the terraces with their remarkably flat surfaces are seamed by deep, precipitous-sided watercourses,[1] dry except immediately after rain. In this "bad land" type of topography it is a wonderful sight to see a "chaung come down," a dry watercourse perhaps 400 yards wide converted into a mass of swirling brown water in the course of a few minutes.

In its course across the dry belt the Irrawaddy swings right round the conspicuous Mount Popa and is joined by the Chindwin. The fall is slight and the current small. Thus the level of high water at Pagan, in the heart of the dry belt, 468 miles by water from Rangoon, is only 170 feet above sea-level: a fall of 4 inches per mile.

(*f*) *Thayetmyo to Akauktaung and Myanaung.*—Below Thayetmyo the crest of the Arakan Yoma approaches within 50 or 60 miles of the crest of the Pegu Yoma and spurs from the two groups are thrown off towards the centre of the valley. Tectonically the area is one of varied and irregular folds, mainly of Peguan rocks. Where the dips are gentle and hard beds are absent, the river tends to ignore the structure; where there are conspicuous sandstone groups, especially if they are steeply dipping, the river is forced into strike valleys and the scenery, striking after the tameness of the middle course from Mandalay to Magwe—it is at Magwe perhaps rather than at Thayetmyo that the change begins—is reminiscent of the higher reaches of the river. In the midst of a comparatively narrow and deep section of one of the strike valleys is the important river port of Prome. At this point the river can be, and is, constantly gauged and the total area of the basin above this point can be calculated.

At Nyaunggyo, about 90 miles below Prome, the first of the delta distributaries, the Bassein river, is given off; but deltaic conditions really begin about Myanaung, 53 miles below Prome. Below Myanaung a calculation of total discharge is rendered almost impossible by the irregular connections between the river and its distributaries as well as by the flooding of its waters over paddy land.

Whilst high cliffs are the exception rather than the rule from Magwe to Myanaung, there is a famous line of sandstone cliffs, carved with innumerable statues of Buddha, at Tonbo below Prome where the ridge known as Akauktaung approaches the river.

(*g*) *The delta.*—The present apex of the delta at Myanaung lies about 58 miles above Henzada. Including the Bassein river, the Irrawaddy enters the sea by nine mouths, but the river "divides and subdivides, recommunicating on each side with streams which have already left it, and converting the whole of the lower portion of its basin into a network of tidal creeks" (Scott). The easternmost mouth, the Rangoon river, is in reality a separate river known in its upper course as the Hlaing and draining the slopes of the Pegu Yoma. Though connected with the Irrawaddy, little or no water from the main river passes down it. Similarly little water from the Irrawaddy itself passes down the Bassein river and it thus happens that the only two mouths

[1] Watercourses, independently of whether they contain water or not, are called in Burmese *chaung* corresponding to the Indian "nullah."

used by ocean-going vessels are scarcely true mouths of the Irrawaddy at all. The bulk of the water is discharged by the Eya mouth.

In detail, the Irrawaddy delta differs very considerably from other great deltas, especially in the way in which it has been and is being built up. From the apex of the delta to the sea is roughly 180 miles, and from the mouth of the Bassein river to that of the Rangoon river is roughly 150 miles. The delta proper, excluding the marginal areas on the slopes of the Arakan and Pegu Yomas, has an area of roughly 12,000 square miles. The most striking feature of this great delta is not simply its flatness, which is to be expected, but its extremely low level. At least 2000 square miles lie below the level of high spring tides, fully as much again only a foot higher. Apart from some small and exceptional ridges, due either to inliers of Tertiary limestones and volcanic rocks or to lateritization of alluvium along slight ridges, probably tectonic,[1] the whole consists essentially of alluvium in which differentiation is difficult. It might be supposed that the delta is being gradually built up by alluvial sediment deposited by the Irrawaddy during the annual flooding. Such is not the case. The whole of the delta is a region of heavy rainfall; practically the whole receives over 80 inches of rain and at least half has 100 inches. The bordering ranges of the Arakan Yoma and Pegu Yoma have considerably more. There are considerable falls in May (mango showers), whilst the bursting of the monsoon in June gives a rainfall only slightly less than that of July, the wettest month. Miss K. E. Bruen, of the University of Rangoon, in an unpublished account of the agricultural geography of the delta, very vividly describes the position as follows:

"The first monsoon showers fill the numerous depressions and *engs* (ins—deserted sections of river bed) which gradually enlarge until the whole country is submerged. The turbid waters of the river do not at first rise to the same height. The land adjoining the river being higher [2] than the flooded interior there exists no way by which the rain waters can be effectively drained off. Next, the lowlands skirting the hills begin to fill with the flood-waters of the mountain torrents which pour down from the Yomas. From the vast quantities of sand brought down, a fringe of talus appears where the foothills meet the plains.[3] In conjunction the rain waters of the plains and the issue of the mountain streams constitute a great body of water that is singularly limpid and free from sediment, though often tinged with brown from decaying vegetable matter. It forms an effective barrier to the silt-laden waters of the Irrawaddy when at length in their turn they have risen and overflowed their banks. Often, as a consequence, the main stream holds its course without mingling and may be traced as a ribbon of colour winding its way through the paler waters of the inland sea. The presence of this watery dam thus tends powerfully to reduce to a minimum the deposition of silt and to confine it to the immediate neighbourhood of the river."

This interesting explanation demonstrates that the bulk of the silt brought down by the Irrawaddy is carried out to the Gulf of Martaban and contributes

[1] On the formation of these ridges see L. D. Stamp, "Some Syriam borings." *J. Burma Res. Soc.* 15 (1925) 171–80.

[2] Partly owing to the construction of protective banks.

[3] On the behaviour of these lateral streams, important because of their use in floating timber, see F. A. Leete and G. C Cheyne, 'Regulation of rivers, etc.' London, 1925.

to the seaward growth of the delta.[1] From a comparative study of the subsurface contours of the Gulf, shown in the Survey of India maps of 1860–70 and 1909–10, Chhibber[2] has concluded that the coast of the delta is advancing at the rate of 3 miles in a hundred years. The present sea coast consists of a line of sand-dunes about 100 yards in width, lying above high-tide mark, sometimes clothed with *Casuarina* trees, and some 3 or 4 feet above the land behind. The actual manner by which the delta advances has been described by Moodie.[3] A number of sandbanks lie some little distance out to sea. The sand is fixed by vegetation: grasses appear first, then mangroves, while they are still below high-water level, and once established, silting takes place rapidly until the sandbank becomes an island separated from the mainland only by a narrow channel. Eventually a junction is made with the main coastline. From evidence available it seems that the sediments are "varved," annual alternations of finer and coarser material being consequent on the strength of the river currents and the salinity of the Gulf waters (which affects flocculation).

The seaward margins of the delta are forested and the sequence of vegetation has been described elsewhere.[4] On land subject to only occasional tidal flooding forests of large trees (especially kanazo or *Heritiera fomes*) can scarcely be described as mangrove swamps. Behind the forests are the great rice lands; rice occupies typically over 85 per cent. of the cropped land, which again is normally two-thirds of the whole delta.

The course of the Chindwin

The Chindwin is the chief tributary of the Irrawaddy, and although navigable for steamers for 300 miles from the confluence, it is the highway into a sparsely inhabited part of upper Burma and is relatively unknown to the visitor. Yet whereas the Upper Irrawaddy is scenically attractive only in certain stretches, the Chindwin is magnificent throughout, for one is rarely out of sight of the succession of giant saw-tooth ridges rising to 3000 and 4000 feet. The headwaters of the streams which unite to form the Chindwin are not far from those of the Mali Hka. After its course through the Hukawng valley the Chindwin flows in a huge arc southwards to Kalewa, following the main trend of the hill ranges. Even in that stretch the Chindwin jumps from one strike valley to another, often by picturesque gorges not without dangerous whirlpools in the high-water season; but this curious behaviour is most marked south of Kalewa. There the way is apparently open by strike valleys to the south and the natural course of the river would seem to be through Pauk to the great Yaw Chaung which enters the Irrawaddy near Lanywa (see

[1] On the other hand there are the usual troubles found where silt-laden rivers have been artificially enclosed by embankments. They tend to silt and so raise their own beds and to erode laterally, thus breaking the banks and causing disastrous floods followed by changes of courses. See Report of the Floods Enquiry Committee, 1924–5. Rangoon, Supt. Govt. Printing.

[2] H. L. Chhibber, 'The geology of Burma,' London, 1934, p. 16.

[3] A. W. Moodie, 'Working plan for the forests of the Irrawaddy delta,' Rangoon, 1925. See L. D. Stamp, "Aerial survey of the Irrawaddy delta forests." *J. Ecol.* 13 (1925) 262–76.

[4] L. D. Stamp, *op. cit. supra*. *J. Ecol.* 1925; also "The vegetation of Burma," University of Rangoon Research Monograph, No. 1, 1925. H. G. Champion, "A preliminary survey of the forest types of India and Burma," *Indian For. Rec.*, N.S. 1 (1936).

Fig. 1). Instead of following this course the river takes a great loop to the north before turning south again to join the Irrawaddy in the heart of the dry belt some 60 miles below Sagaing. Its lower course, from Kani to the confluence, takes on the character of the middle course of the Irrawaddy.

It was my privilege to spend two field seasons in geological mapping in the

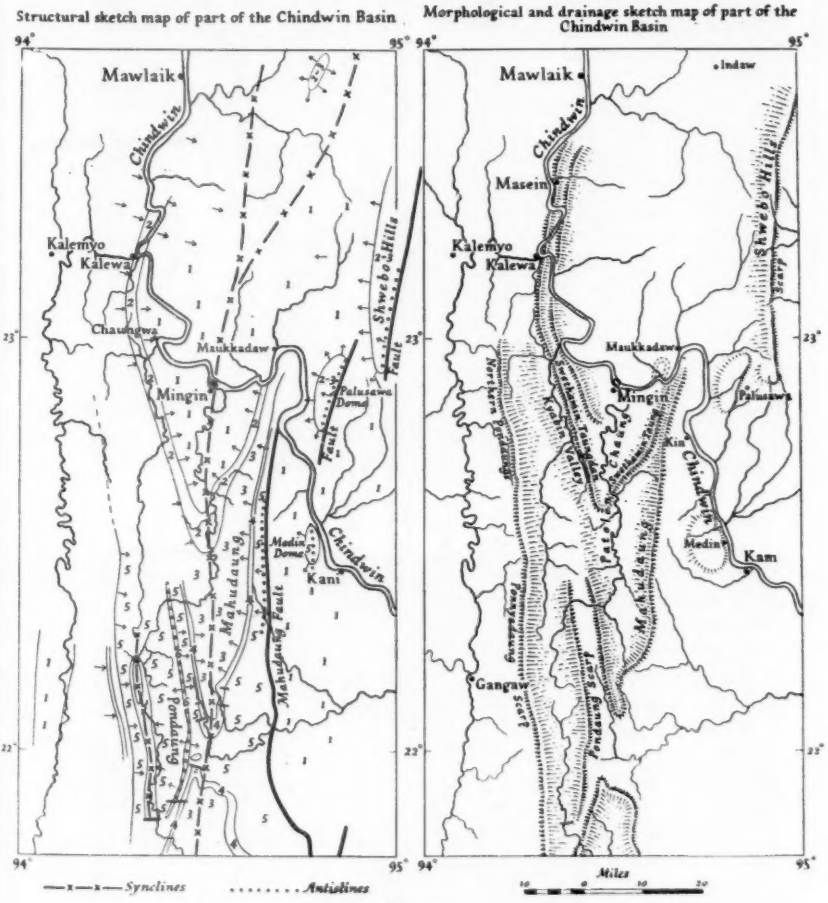


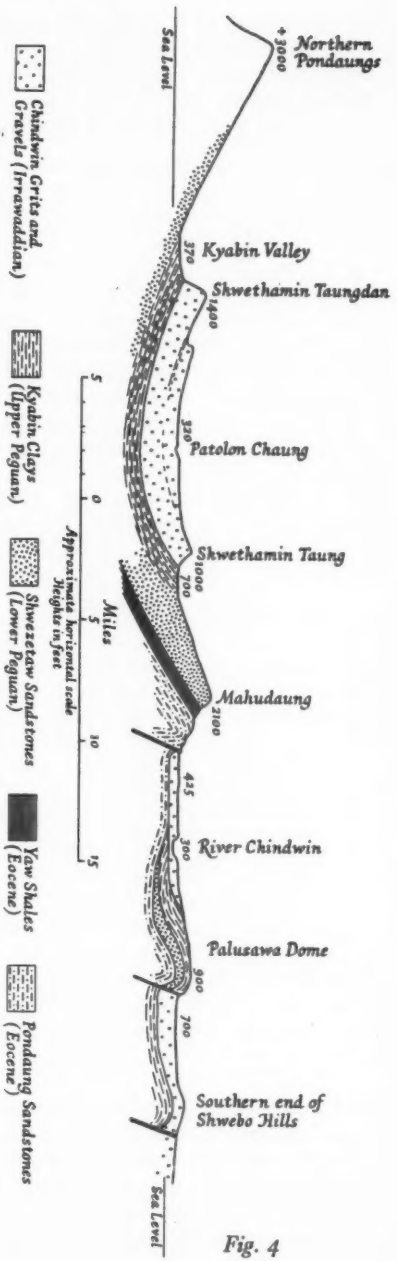
Fig. 3

Lower and Upper Chindwin districts and to revisit part of these areas in 1938, so that the course of the river from just above Kalewa to Kani has been selected to illustrate some general features of the river's course. So far as I know no geological map of this area has previously been published (except for a sketch-map of my own in 1922 which needs correction), though it must have been mapped by more than one of the oil companies.

Structurally the upper Chindwin district consists essentially of a broad syncline of which the centre is occupied by unconsolidated false-bedded sands, grits, and conglomerates with claybands: the Chindwin Grits of Irrawaddian or Mio-Pliocene age. To the west rise a series of strike ridges with precipitous scarp edges facing westwards and dip slopes of varying degrees of steepness to the east. Each sandstone outcrop forms a ridge, each clay or shale horizon a valley. On the east the Chindwin syncline is bounded by the Shwebo hills with a bold scarp face to the east, overlooking a lowland. Near the foot of the hills is a great boundary fault.

South of Mingin the syncline narrows and there is a marked northerly pitch. This part is frequently called the Patolon syncline from the stream which flows northwards near its axis. It is bounded on the east by the great Mahudaung scarp, in structure similar to the Shwebo hills, though the boundary faults are not continuous but echeloned.

The structure is shown in Fig. 3 and the section Fig. 4. This map corrects in certain important particulars the sketch-map I published in 1922 and adds the results of work carried out in 1938. Above Kalewa the river flows in strike valleys, bounded by scarp faces on the east and steep dip slopes on the west of sandstones with an average dip of about 25–30 degrees. At Kalewa the Chindwin is joined by its only



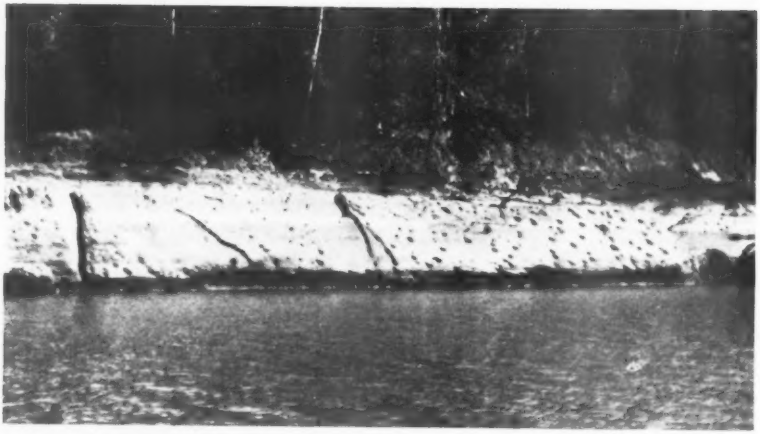
Section approximately along Lat. 22°50′

Fig. 4

The Myittha, between Kalemyo and Kalewa

The Chindwin: approach of a dry season depression

Small potholes in shale at Mingin, on the Chindwin



Cliff face scoured by oblique potholes or grooves

Large potholes of normal type at base of cliffs on the Chindwin

considerable tributary, the Myittha, which receives the drainage of the Chin Hills. The Myittha is navigable between Kalemyo and Kalewa and passes through a magnificent gorge at right angles to the strike of a great sandstone ridge. Apart from this gorge, major breaks through the north–south ridges are few. Yet this short course might be called a consequent river dependent on the uplift of the Arakan–Lushai–Chin–Manipur–Patkai Hill groups.

It is south of Chaungwa (where the Taungdwin Chaung cuts in a fine gorge through the Shwethamin ridge) that the Chindwin swings in a great arc, in rough conformity with the outcrops of the grit beds at the base of the Chindwin series which give rise to the Shwethamin scarp. The river then escapes from the syncline by swinging round the northern end of the Mahudaung scarp, roughly where that great hill range and the accompanying Mahudaung boundary fault both die out.

The Chindwin grits and sands which occupy the centre of the syncline were doubtless deposited by the ancestor of the present river and the natural course of the Chindwin would appear to be due southwards along the line of the Patolon Chaung and eventually into the Kyaw river past Pauk. Late Pliocene uplifts seem in the neighbourhood of Kalewa to have crystallized pre-existing meanders by forcing them into strike valleys amongst the newly uplifted ridges. Farther south, almost exactly in latitude 22° N., the formation of a saddle in the midst of the main syncline[1] interrupted the drainage so that the Patolon Chaung now flows northwards into the main river near Mingin and the Chindwin itself was forced to swing northwards again, eventually escaping to the heart of the Irrawaddy basin between the northern end of the Mahudaungs and the southern end of the Shwebo hills—actually between the minor tectonic uplifts of the Medin and Palusawa domes. Even here, below Kani, late Tertiary or Quaternary volcanic outbursts (producing the famous explosion craters of Twindaung and other hills) threw out lavas and ash beds which constrict the river, for a few yards, to a width of only about 100 yards.

The regime of the Irrawaddy

Amongst the early accounts of the Irrawaddy, those of Colonel Yule are of special interest.[2] He described the flood of 24 August 1855 at Ava (Mandalay) and estimated the discharge of the river there at 900,000 cusecs for ordinary high water and 1,200,000 for the extreme high flood which he witnessed.

The rice lands of the Irrawaddy delta are dependent on protection from excessive flooding, and as early as 1863 protective works were begun. Gordon carried out careful river gauging from 1869 to 1879, and summarizes the results in his paper quoted above. From 1 August 1872 to 1 August 1873, daily measurements were made (Sundays excepted) at "Talokmoh" (presumably Tarokmaw of modern maps, 38 miles below Prome), near the head of the delta where all the water passes through a single channel about 500 yards wide. The measurements were checked against others taken 110 miles lower down in the main channel and in the Bassein channel. During his period of observations Gordon records the maximum flood discharge in one

[1] See map in L. D. Stamp, *Trans. Min. geol. Inst. India* 17 (1922) plate 14; shown also in G. de P. Cotter, *Mem. geol. Surv. India* 72 (1938) plate 7.

[2] H. Yule and T. Oldham, 'Report of the Mission to Ava,' pp. 63–83. Calcutta, 1856.

day as 2,000,000 cusecs (1877); the minimum 50,000 cusecs. He gives his main results in cubic yards; translated approximately into the more usual cusecs the following result is obtained:

Average monthly discharge of Irrawaddy near head of Delta, 1869–1879

Jan.	105,000 cusecs	2·00 % of annual carrying	2·4 million tons silt
Feb.	82,000	1·42	1·1
Mar.	84,000	1·59	1·3
April	115,000	2·11	3·2
May	158,000	3·01	7·1
June	412,000	7·58	21·6
July	986,000	18·74	51·5
Aug.	1,152,000	21·89	69·7
Sept.	988,000	18·19	50·3
Oct.	751,000	14·29	35·5
Nov.	322,000	5·93	11·3
Dec.	170,000	3·24	6·3

Thus Gordon found the total mean yearly discharge to be 521,794 million cubic yards (an average of 447,000 cusecs), or four-fifths of the total then

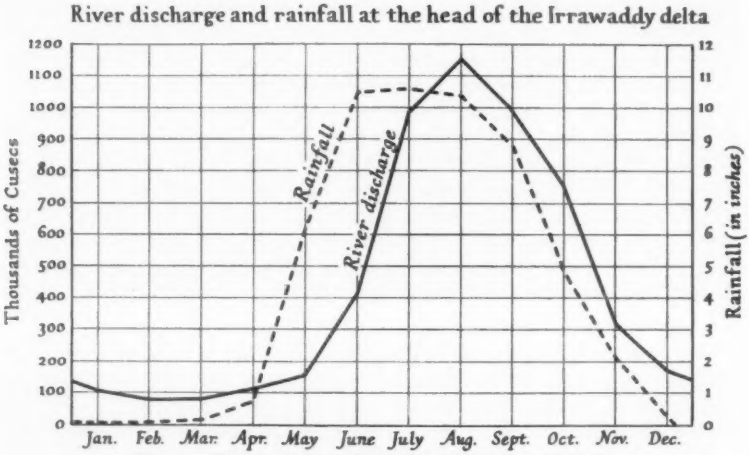


Fig. 5. Figures for discharge from Gordon, 1869–79

known for the Mississippi, and the total of silt carried seawards at 261 million tons. These calculations being based on measurements at the head of the delta exclude the additions made by the heavy rainfall of the delta. Gordon was naturally concerned with the regime of the river at the point where his protective works were to be constructed. With the extension of navigation to Upper Burma interest shifted to the river's higher reaches. The records kept by the Irrawaddy Flotilla Company are thus complementary to those of Gordon.

Bhamo, approximately 900 miles from the sea,[1] is the normal head of

[1] According to the mileage charts of the Irrawaddy Flotilla Company, 872 miles by water from Rangoon.

steamer navigation on the main Irrawaddy. It is accessible to the steamers of the Irrawaddy Flotilla throughout the year and the steamer traffic from Bhamo downstream to railhead at Katha has a special importance as an essential link in the normal, and indeed only regular, means of communication between Rangoon and the jumping-off ground for the Yunnan land route. The regime of the Irrawaddy at Bhamo has thus been of first importance to the Flotilla Company and a river gauge has been in operation for many years, daily reports being telegraphed to Rangoon. Complete manuscript records from 1907 to the present have been preserved in the company's offices in Rangoon. Day-to-day monthly graphs have been superimposed for sets of years (1907–1915, 1916–1922, 1923–1928, and 1929–1934), but no average figures are available. The figures were therefore roughly averaged and afforded the data for Fig. 6. These show a considerable consistence. Low water occurs normally in February followed by a gentle rise and then a steeper rise in April, consequent on the melting of snows on the border mountains. The water-level is more than maintained during May, but there is an extremely sharp rise in June with the breaking of the monsoon. The highest level is reached towards the end of June or early in July, after which the level falls steadily, though the fall tends to be checked by late rains in September. The normal rise and fall of the average monthly river levels during the year is about 20 feet. These average graphs do not however express the great range which is possible. Highest and lowest recordings during the period 1907–1936 are accordingly shown by vertical lines on the graph which has an extreme range from 6 feet 9 inches to 43 feet 3 inches on the gauge—a range of $36\frac{1}{2}$ feet. Day-to-day movements of river-level may mount to as much as 5 feet, and a typical monsoon month (August 1933) has been shown in graphical form in Fig. 7.

The largest steamers of the Irrawaddy fleet[1] are the express mail steamers plying between Rangoon and Mandalay. From Rangoon they reach the main river through canalized delta creeks and first or second-class passengers bound for the towns of central Burma (the dry belt) usually join the up-steamer at Prome—160 miles by rail from Rangoon—after an overnight train journey. The level of the river at the busy junction port of Prome is important as affecting the position of the landing flats as well as all river traffic. It is recorded and, normally, published daily in the *Rangoon Gazette*. From Prome to Mandalay—some 334 miles—the main river channel is kept surveyed and buoyed by the Company. In the low-water season there is always a likelihood of grounding on one of the constantly shifting sandbanks, but normally there is adequate depth in the main channel, and so river gauging was not considered of major importance. After the construction of the Ava

[1] The Irrawaddy Flotilla Company Limited was formed in 1865 to implement a contract made with the Government of India for the conveyance of troops, stores, and mails to riverine stations of British Burma and to operate a general service to Mandalay, then the capital of independent Upper Burma. It started with four rather unsuitable steamers and three flats taken over from the Government. By a new contract of 1868 the service was extended to Bhamo. The company has now over 600 steamers, including express steamers 326 feet in length and oil flats carrying 800 tons of crude oil, and carries in a normal year 8,000,000 passengers and 1,200,000 tons of cargo.

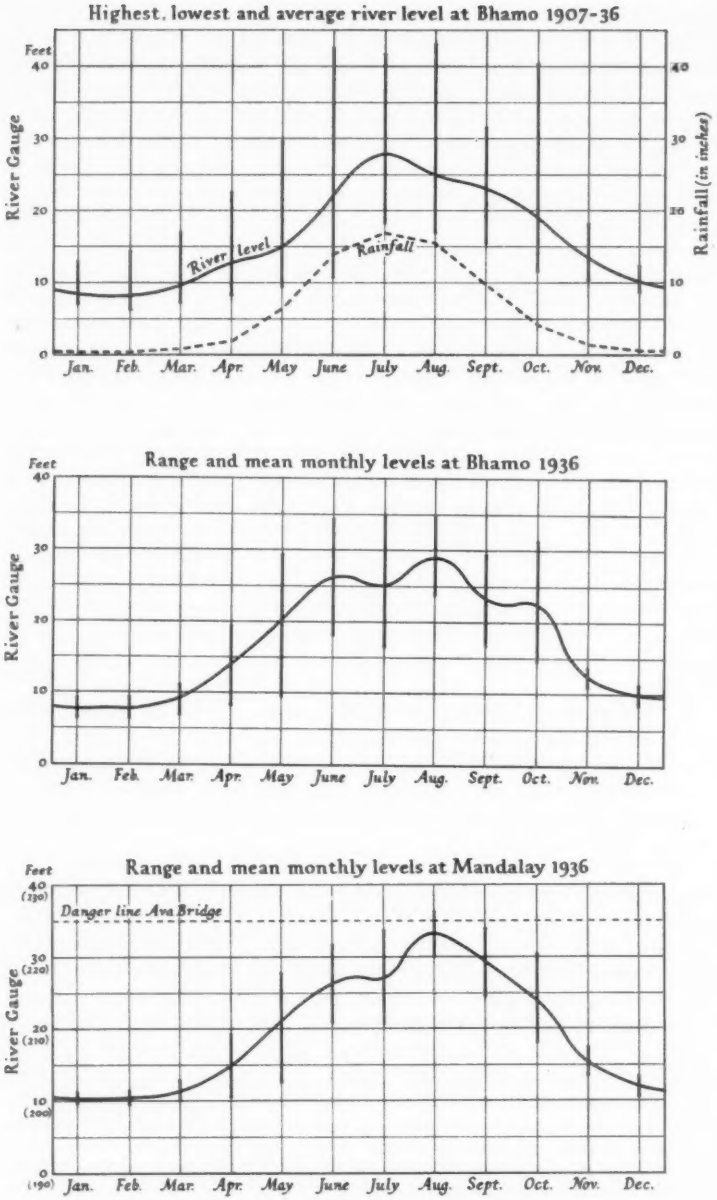

Highest, lowest and average river level at Bhamo 1907-36
Feet
River Gauge
Rainfall (in inches)
River level
Rainfall
Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec.
Range and mean monthly levels at Bhamo 1936
Feet
River Gauge
Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec.
Range and mean monthly levels at Mandalay 1936
Feet
Danger line Ava Bridge
River Gauge
Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec.

Fig. 6

road and rail bridge just below Mandalay, opened in 1933, a new and unexpected difficulty arose. It was found that with exceptionally high water there was insufficient clearance under the bridge, so that high water became the danger, not low. Gauging at Mandalay suddenly became of great importance. As might be expected, fluctuations in river-level at Mandalay reflect those at Bhamo; the average rise and fall is about the same (21 or 22 feet), but the extreme levels are between narrower limits. Thus (Fig. 6) for the year 1936 the extreme differences at Bhamo were 28½ feet; at Mandalay 26 feet 10 inches. It is however the violent day-to-day movements at Bhamo which have become much less marked by the time the water reaches Mandalay (Fig. 7). Some of the violent fluctuations at Bhamo scarcely reach Mandalay

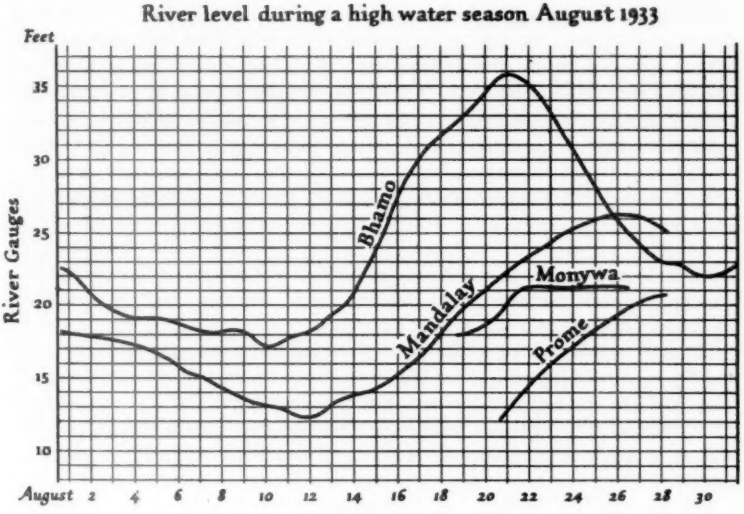


Fig. 7

at all. In June 1933 a rise of 10 feet in ten days at Bhamo took eight days to reach the bridge and was reduced to 9½ feet. In August 1933 a rise of 18 feet 7 inches at Bhamo in eleven days was reflected as a rise of 14 feet 5 inches at the bridge in fifteen days, the top of the rise occurring at the bridge six days after Bhamo. In May 1936 the gauge at Bhamo rose from 18 feet 11 inches on the 29th to 29 feet 5 inches on the 31st, but only a slight rise reflected this at Mandalay. In October 1936 a rise of 8 feet 8 inches in twenty-four hours occurred at Bhamo (October 5–6) and became one of 6 inches at Mandalay nine days later. Even in the low-water season there may be sharp rises at Bhamo. Thus a rise of 2 feet 3 inches in twenty-four hours, 24–25 December 1936, was reflected as a rise of only 9 inches at Mandalay.

Whilst the graphs for Mandalay are thus for the most part feebler counterparts of those for Bhamo, there is an interesting complication. Although the mighty Chindwin joins the Irrawaddy some 60 miles below the Ava bridge

the gradient is so slight that a heavy discharge of the Chindwin causes a ponding back of the waters of the main river and may result in dangerously high water at the bridge unconnected with the movement of the level at Bhamo. Similarly the waters of the Chindwin are ponded back by a rising Irrawaddy (see the graph for Monywa on the Chindwin in Fig. 7).

River regime and rainfall

Very naturally the regime of the Irrawaddy reflects faithfully the rainfall regime. If the rainfall graph for Bhamo (Fig. 6) is compared with the river-level it is found that there is very close correspondence, except for the early rise of the river in April due to melting snows. Fig. 5, the graphs for Myanaung at the head of the delta, show exact correspondence except that the river curve is roughly one month behind the rainfall. The total area of the Irrawaddy basin is approximately 158,500 square miles, of which 144,000 square miles lie above the head of the delta. Some calculations based on the area above the delta show that if the average rainfall is 75 inches the weight of water falling there is $929 \cdot 10^{10}$ tons; the total discharge (Gordon's average) is 522; whence the evaporation is 407, or 33 inches of water in the year.

Even the figure of 33 inches is a relatively low one for evaporation. Very little water is received by the main river from the junction of the Chindwin to the head of the delta; that is, over the dry belt where the rainfall ranges from 20 to 40 inches a year and is accordingly but little, if any, more than the average evaporation figure. But evaporation is probably much greater than in the wetter forested regions of the north.

At present little water is used from the main river for irrigation. There is clearly an abundant supply available for the extension of irrigation in the large alluvial areas of the dry belt, but these represent but a fraction of the total area of the dry belt itself. The terrace topography limits possible irrigation to about 20 per cent. of the total area with a rainfall of under 40 inches.

Some remarks on the mechanism of erosion and deposition

In the Chindwin valley north of the dry belt one is left in no doubt that practically all the erosion carried out by the river and its tributaries takes place in the wet season. In the dry season the courses of all but the largest tributaries are almost or completely dry. In the rains they become irregular or intermittent raging torrents. There are no roads in this part of Burma; the bullock carts, all of the same gauge, with two bullocks walking in exactly the same tracks as the wheels, cut out double channels in the harder rocks and double gulleys of dust in the softer. In the rains these tracks, especially in hilly districts, become double watercourses. All alike exhibit one feature in common: the paramount importance in all harder rocks of "pot-holing." The stream courses are frequently an almost continuous succession of pot-holes of all sizes. Huge ones occur at the foot of rock falls (the so-called "plunge pools") and hold water throughout the year; boulders may hide the stream bed, but where the rock floor is exposed it is usually pot-holed.

Still more remarkable however is the evidence afforded by the Chindwin itself. Beds of shale exposed during the low-water season show pot-holing wherever a few pebbles have been arrested. These pot-holes are generally of the type shown in the plate facing p. 345, a few inches across and a few inches deep. Wherever (usually of course on the outside of a convex curve) there is a cliff or sandstone face washed directly by the waters of the river, that face is scoured by oblique pot-holes. These are usually only a few inches across, often many feet deep and always at a definite angle so that those on a given cliff face are all parallel. It would seem that the uniformity of size and direction is to be explained by the power of the river, at a given velocity, to carry in suspension small stones up to a certain size which are washed against a vertical or steep rock face. Wherever there is a slight projection they are held up and a pot-holing action begins. It is just as if a series of mechanical augurs had been at work, splitting off considerable blocks. It would also seem that many of the grooves seen on the cliff faces in the dry season are scoured out on the surface and have never formed real tubes. At the base of these cliffs are large pot-holes of the ordinary type. This type of erosion has been emphasized here since physiographers seem inclined to regard pot-holes as relatively incidental features. Thus Lobeck[1] says: "these are not features of topographic importance . . . undoubtedly more is accomplished by breaking off large blocks by hydraulic action along joint planes." The Chindwin suggests a different mechanism.

The nature of deposition in the delta has already been considered. In Burma a special importance attaches to the numerous sandbanks which are exposed during the low-water season, as crops such as tobacco, maize, and beans are planted on the fertile layer of silt left as the river falls. In section the sandbanks are seen to have alternating sandy and clayey layers, the latter holding up water. The surfaces of the layers usually dip gently downstream. When the water falls mud-lined hollows are left on the surface of the bank and form relatively infertile patches which only gradually dry up.

Accepting Gordon's average of silt carried at the head of the delta at 261 million tons per annum, to which may be added 48 million tons of dissolved matter, the Irrawaddy ranks as one of the fastest eroding major rivers in the world. Yet the erosion is not, as might be expected, in the young upper reaches. At Mandalay the total silt passing has been calculated at 32 million tons. To that 229 million tons is added in the course through the dry belt. Of this 109 million tons is received from the Chindwin, but no less than 120 million tons, nearly half the total, is contributed by the non-perennial streams of the dry belt. Here nearly all erosion takes place as a result of sudden storms. In not more than ten minutes a dry stream bed, anything from a few yards to 1000 yards wide, is converted into a mass of swirling muddy water several feet deep, sweeping all before it. When a chaung comes down the noise of the approaching water can be heard some distance away and there is not infrequently a wall of water, resembling a bore, rushing over the dry sandy bed. The whole basin of the Irrawaddy is being lowered at the rate of an inch in four hundred years, but it is safe to say that in the terraced land of the dry belt the speed is ten times this amount.

[1] A. K. Lobeck, 'Geomorphology,' p. 195. London, 1939.

THE IRRAWADDY BASIN

Total area of basin	158,500 sq. miles
Basin of the Mali Hka	8,950
Basin of the 'Nmai Hka	9,900
Total area of Irrawaddy basin above Bhamo	28,500
Basin of the Chindwin	44,050
Total area of Irrawaddy basin above Prome	139,900
Area of Irrawaddy basin below Prome	18,600
Area of Delta proper	12,000

Areas approximately calculated from 1/M Survey of India maps.

DISCUSSION

Before the paper the CHAIRMAN (Mr. LEONARD BROOKS) said: Dr. Dudley Stamp needs no introduction to Fellows of this Society. He lived in Burma from 1921–26, and was in 1923 appointed as first Professor of Geology and Geography in the University of Rangoon. He has since those days returned to Burma and visited and studied old haunts. I think that is all I need say in preparation for what I am sure will be a most interesting lecture.

Dr. Dudley Stamp then read the paper printed above, and a discussion followed.

The CHAIRMAN: Would Dr. Cotter, who was in charge of the Burma Party of the Geological Survey of India, add a word or two on the subject?

Dr. G. DE P. COTTER: I should like, first, to say that I thoroughly agree with what Dr. Stamp has said, and I congratulate him on the very clear manner in which he has made all his points. Everybody now accepts his view of the original alignment of the Proto-Irrawaddy. It was a river combined of the present Chindwin and the Lower Irrawaddy, and at one time or other it was supplied by the waters of the Tsangpo in Tibet, which escaped through the Hukawng valley. That theory was put forward in 1912 by Sir Edwin Pascoe.

Dr. Stamp said that the tributaries of the Proto-Irrawaddy tend either to skirt the anticlinal folds or cross at the saddles. That seems to me to be usually the case in this part of Burma, but there is the curious exception, to which Dr. Stamp referred, in the Pagan and Gwegyo Hills. These hills are peculiar in that there are a number of small streams which cut directly across them. I would like to hear Dr. Stamp's explanation of this curious exception.

Dr. Stamp has explained that at one time the Peguan gulf was a twin gulf in Burma; that is, at the close of the Miocene period there were twin gulfs separated by the land which subsequently formed the Pegu Yoma. The gulf to the east is probably of late origin, certainly not older than the Miocene, and the rocks are of Middle Miocene age upwards. Nothing earlier has been found. The gulf to the west is older. I think it dates from the Palaeocene, and, taking the alignment of the Eocene gulf, I think we must place it decidedly to the west of the Peguan gulf; this conclusion is worked out from the conditions of the sedimentation of the Eocene. There are marine sediments to the west near Pasok and decidedly freshwater types of sediments to the east near Myaing.

Dr. Stamp also suggested that the original course of the Chindwin was *via* the Patolon Chaung–Kyaw Chaung, continuing down to the Pauk syncline to the great Yaw Chaung, or more or less along that alignment. Now, at Chaingzauk at the head of the Pauk syncline, which is part of the supposed original course of the Chindwin, there were found some years ago a number of mammalian teeth of Pliocene age, *Mastodon*, *Stegodon*, etc. In the deposits near the village of

Taungbyinngè, on the Chindwin, Mr. A. E. Day found also a number of mammalian teeth. They contained earlier types of *Elephantidae*, *Hemimastodon*, *Dinotherium*, etc., and they are much older than the mammalian remains found around Chaingzauk. Therefore the Proto-Chindwin must have been flowing down its present course at an earlier date than when it flowed through the Pauk syncline. In other words, the Irrawaddian rocks of the Lower Chindwin district near the present course of the river are older in part at least than those of the Patolon–Kyaw alignment. The history of the river is therefore not simple. It has probably had different courses at different periods, and it would be difficult to trace out any definite history for it.

Dr. Stamp has told us that the Lower Irrawaddy flows between the Arakan Yoma and the Shan plateau. We have had some discussions previously on the nature of the boundaries. I believe Dr. Stamp at one time put forward a theory that there was a rift valley, but I think he has now dropped it. At any rate, the western boundary between the Tertiaries and the Arakan rocks does not show a boundary fault. Mr. Clegg and I have been all over that boundary and found no evidence of such a fault. Dr. Stamp suggests that the eastern boundary may be faulted. There are hardly any sections which show a junction between the Tertiaries and the rocks of the Shan plateau. The junction is completely concealed by alluvium, as far as I know, except north of Mandalay, where Dr. Iyer found some faulting. I would suggest that if there is a boundary fault it is probably reverse faulting, showing compressional movement and not tensional.

With regard to the terraces described by Dr. Stamp, I met Dr. de Terra and Dr. Mobius in Burma when they were working out these terraces, and I think that their sequence is correct for the country around Yenangyaung, Gwegyo, and Mount Popa, but I should not like to generalize about it. If it is taken as an interpretation of the terraces in the Yenangyaung–Gwegyo district I think we can accept it.

Captain F. KINGDON WARD: My knowledge of the Irrawaddy, geographically speaking and in no other sense, begins where Dr. Stamp's ends. He mentioned Myitkyina, the head of navigation 1000 miles up the Irrawaddy. From Myitkyina I have generally started on my expeditions. To get from the sea to Myitkyina by the quickest route, the railway, took three days; from there it is something like 400–500 miles to the several sources of the Irrawaddy, and the journey over that last 400 miles or so meant not three days' travel but about three months. It is one of the wildest and greatest tangles of mountains, forests, river gorges, and glaciers in the world.

At the commencement of his paper Dr. Stamp mentioned a most significant fact. I admit that I heard with considerable surprise, and may I say with not a little scepticism, that the snowfall in the region has such an exceedingly small effect upon the Irrawaddy. The river rises from glaciers. It is true that they are not very extensive glaciers, but there are a large number of them. The amount of snowfall up in this tangled last 300 or 400 miles of the Irrawaddy river is surprising. I suggest that possibly Dr. Stamp has got his timing a little wrong; that the synchronization between the rises and the melting snow and glaciers is not quite correct. I feel I have to stand up for my glaciers, because I had to cross a great many of them. Assuming that all the glaciers, the snowfields, and the snowfall were wiped out, it would be interesting to note what happened. I cannot help thinking that Dr. Stamp would find a considerable difference in the Irrawaddy at Myitkyina—I am not so sure about lower down—if all these sources of water suddenly disappeared. I should like Dr. Stamp to amplify a little his remarks on the effect of snowfall on the Irrawaddy basin.

The CHAIRMAN: I will ask the Secretary to read a letter from Sir Edwin

Pascoe, a former Director of Geological Survey in India, who was not able to be present this afternoon.

Sir EDWIN PASCOE: We are still very much in the dark as to the age of the rocks in the Arakan Yoma, a region which has an unenviable reputation from a health point of view. Cotter was inclined to support the old idea that the rock sequence included pre-Cambrian examples, but Clegg has recently cast doubts on this conclusion. The work of recent years in the Himalaya by West and Auden has also shown that degree of metamorphism is an unreliable clue to age in a much-folded area, and we can no longer conclude that the crystalline core of the Arakan Yoma is pre-Cambrian because it is crystalline. The oldest rocks in this range actually identified were supposed to be Triassic, but Clegg has gone very carefully into this point and believes that the specimens of *Halobia Lommeli* thought to have been collected from the Yoma really come from Karenni. The result is that we are not certain that there is anything older than the Cretaceous.

The Mogok limestones have up to the present been regarded as Archaean. Clegg's provisional claim that they are much younger is based on the fact that these limestones occur in the same line of strike as limestones which have yielded fossils. It is not certain however that we are dealing with the same limestones in the two areas, which are several miles apart.

Dr. Stamp is very cautious in diagnosing the early history of the upper portion of the Chindwin–Irrawaddy, and contents himself with the suggestion that it had its headwaters in central Asia. Is it not permissible to suggest that the immediate ancestor of the upper part of the great Burmese river was the Tsangpo? The Tsangpo valley, so far as the evidence goes, is a structural feature which dates back well into the Tertiary. If the Tsangpo has for any length of time flowed in an easterly direction, and there is no good reason to think otherwise, where was its outlet before it was captured by the Brahmaputra? It could not have continued eastwards across China if the Chindwin–Irrawaddy rose in the country farther north, for the two rivers would then have crossed each other. It seems to me comparatively safe to deduce that the Tsangpo originally formed the upper part of the Burmese river. Tributaries from more northerly parts of Tibet may have contributed to this river system, but none of them is likely to have been as large as the Tsangpo.

I am glad to be corrected by Dr. Stamp on one point. I had accepted without demur the statement that the unusual rise in the Irrawaddy at certain seasons of the year is due to the melting of the snows. This rise in the level of the river is sometimes disconcerting. I remember pushing up one of the small tributaries overnight, hoping to get some duck shooting, and waking at dawn to discover that the stream was flowing the wrong way. There was a current strong enough to carry my boat from the main river to the lake drained by the tributary.

I often think that the rocks of a river valley have a marked influence on the temperament of the people inhabiting it, and no better illustration could be found than that afforded by the Irrawaddy. The Irrawaddy Sandstone, the predominant geological series of the Irrawaddy valley, is a bright, clean formation with gay colouring, typical in its joyous aspect of the Burmese people. Contrast this with the thickly populated alluvial valley of the Ganges, where, in spite of the sun, everything is drab and sombre. Serious and sombre are the two adjectives which seem to describe best the temperament of the Ganges peasant. Is this mere fancy or is it cause and effect?

[*The following communication has also been received by the Editor.*]

Mr. D. L. LINTON: In bringing together from his own work and other sources all the essential known facts about the Irrawaddy, Dr. Stamp has pro-

duced a paper of a kind which is too seldom seen. The geography of mountain ranges is well developed, but the study of rivers attracts a much smaller body of devotees. The paucity of precise knowledge about the great rivers of the globe is one of the most serious gaps in our understanding of the lands.

In his discussion of the evolution of the stream two events stand out: the separation of the present basin from the supposed Central Asiatic headwaters, and the separation of the Upper Irrawaddy from the Sittang. Both require further investigation. Regarding the first I would like to ask whether Dr. Stamp would regard the Hukawng valley, which lies transversely across the general trend of the Upper Chindwin and may one day provide through rail communication between the Brahmaputra and the Upper Irrawaddy, as being like the 'Nmai and Mali headstreams of the Irrawaddy of presumed antecedent origin. If it is indeed of this nature it may well have led the Tibetan Tsangpo into the Upper Irrawaddy at some stage in early Tertiary times.

With regard to the separation of the Upper Irrawaddy from the Sittang, it is clear from the account given by Dr. Stamp that peneplanation has occurred both extensively and frequently in the region where the diversion occurred. Slight warping of a peneplane of more than average perfection of development would no doubt permit of a major change of course. It seems reasonable to ask whether there is any evidence of uplift along the line of the general watershed which crosses the Shan Plateau from north-east to south-west, and its prolongation farther south-westwards to the Sittang water-parting.

The ratio quoted by Dr. Stamp between the solution and suspension loads carried by the Irrawaddy (roughly 1–5) offers striking evidence of the velocity and character of the erosion going on in its basin. Baulig has estimated that in the eastern U.S.A. more material is removed by the rivers in solution than is carried in suspension. Here the solution load would be increased by the higher solubility of silicate materials at tropical temperatures, but partly decreased by the smaller proportion of carbonate rocks in the basin and their smaller solubility in warmer water. The Irrawaddy must be at least as effective in removing matter in solution as the American streams, from which it follows that it is some five times as effective in mechanical erosion and transport.

Dr. DUDLEY STAMP: With regard to the behaviour of the river relative to anticlinal uplifts, I conceive the explanation to be something like this: There was a river meandering, as rivers do, across the peneplane before the rise of some of the ridges. Assuming a ridge to be formed gradually by anticlinal uplift, there would be two alternatives: one, that the course of the river would be changed so as to allow the river to flow round the pitching end of the fold. That undoubtedly takes place in the Chindwin, as I tried to demonstrate. On the other hand, if the rise of such a ridge were slow, it is clear that the river might keep pace by cutting down its original bed. I suggest that one has in the Irrawaddy and its tributaries both those phenomena. In certain cases therefore, as for example at Lanywa, the main Irrawaddy river cuts right across an anticlinal fold.

It is difficult to trace out in the present state of our knowledge anything like a definite history of the Chindwin. I was interested to be reminded of the fossil evidence of the age of the gravels north and south of the uplift along 22° N. and to hear the suggestion that the Chindwin–Irrawaddy, though responsible for the deposition of both groups, cannot have done so at the same period of its existence.

I often feel that it should be one of the privileges of a scientific author to publish from time to time a recantation of what he said in some remote and distant past. I admit having once thought of the Irrawaddy valley as a rift valley, but conceiving a rift valley simply as a valley bounded on either side by

faults. This is an incomplete conception: a rift valley implies tension, a pulling apart and dropping of a block of the Earth's surface; whereas it is perfectly true, as Dr. Cotter has said, that in the case of the Irrawaddy basin one has the reverse: compressional faulting. I doubt very much whether the faults which I once conceived as existing on either side of the basin really exist. I certainly would agree most heartily with Dr. Cotter that the term "rift valley" applied to the whole central area of Burma is wrong, and I do not think it matters a great deal whether the margin on either side is a normal junction or whether there is a certain amount of reverse faulting. The supposition would be that there is at least some reverse faulting in places.

With regard to Captain Kingdon Ward's remarks, I am not clear from his observations as to when the melting of the snow and ice in the glaciers takes place in these northern areas. That seems to me to be a crucial question.

Captain KINGDON WARD: The melting generally lasts from April to September.

Dr. STAMP: I rather conceived of the melting in the spring, in April, as so often happens. One would then expect a marked rise in the river in the early part of the year. If, as Captain Kingdon Ward has said, melting goes on during April, May, and June, it would add to the monsoon rainfall; the two would be mixed up together. Therefore I think we are both right, only the river does not make the expected early rise; the effect of melting snow is simply to accentuate the rise due to monsoon rainfall.

Captain KINGDON WARD: I think that is correct.

Dr. STAMP: I am very pleased indeed that Sir Edwin Pascoe has expressed agreement on most of the points put forward. The growing tendency seems to be, as he suggests, to believe that the folding which determined the general form of the basin of the Irrawaddy was Late Cretaceous in age. One used to think of the Indo-Malayan mountains of the Shan States as having Archaean rocks and being much older, but the newer conception seems to put them in line not only with what one knows of the folds farther south in Malaya, but possibly links up with the intrusion of the great granite masses of Tenasserim and Malaya and with the manifestation of volcanic activity in India (the Deccan lavas): all probably different phases of the same orogenic activity.

Mr. Linton had not seen my maps, but they show that I agree in regarding the Hukawng valley as of antecedent character and mark the upper course of the Proto-Irrawaddy as following the Dihang gorge course of the present Brahmaputra. I agree that my paper does little more than touch the fringe of a vast subject and much remains for investigation. In particular I have not attempted to deal with the Taping, Shweli, Madaya, Myitnge, and other east bank tributaries of the Upper Irrawaddy. The dominant trend of these streams agrees with that of the main Shan States divide (north-east to south-west). In part this coincides with the strike (as of limestone bands in the Mogok gneisses) and some of the sudden changes in direction are explained by faults, but such features as the south–north course of the lower Shweli call for further study. I am inclined to agree that separation of the Upper Irrawaddy–Sittang coincided with the erection of the general water-parting in the southern Shan States.

The CHAIRMAN: It is now my duty to ask you to accord thanks to Dr. Dudley Stamp for a most interesting and instructive lecture.

A JOURNEY ALONG THE CHINESE-TIBETAN BORDER

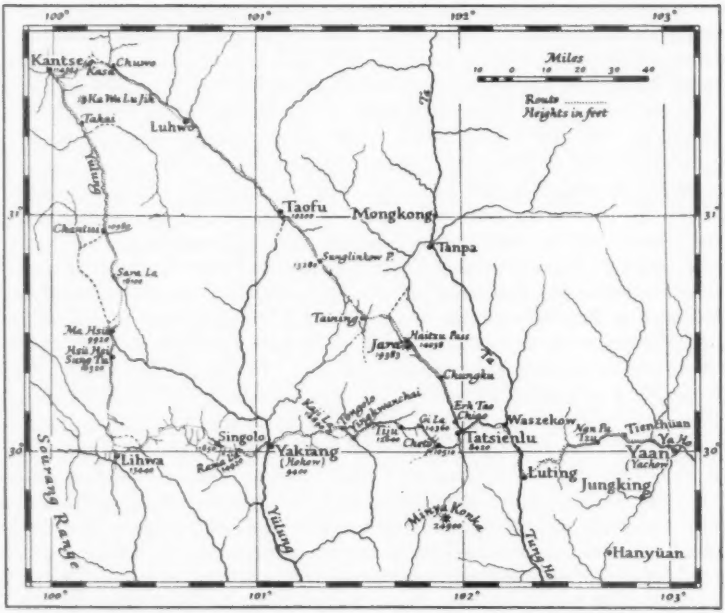
J. HANSON-LOWE

DURING the spring and early summer of 1937 I visited south-eastern Tibet to study geomorphological problems, and particularly the question of Pleistocene glaciation. The results of these investigations will be published later; this paper is merely a general description of the area traversed and the conditions of travel there. The investigation was carried out under a Government grant awarded to me by the Royal Society. I would like to acknowledge my indebtedness to Dr. J. S. Lee, of the Institute of Geology, Academia Sinica, who extended the greatest possible help, particularly in procuring special passports; to Mr. Floyd Johnson, of the S.D.A. Mission, who accompanied me; and to the Reverend and Mrs. Cunningham, of the China Inland Mission at Tatsienlu, whose help and interest can never be forgotten.

To the west of the fertile Red Basin of Szechwan lie the Great Snowy Mountains, the Ta Hsüeh Shan, with Minya Konka rising to nearly 25,000 feet. Still farther west, behind this formidable barrier and reached by passes several thousand feet high, stretches the high plateau of Sino-Tibet with its infinite grasslands, great canyons, and occasional mountain chains that vary its unending undulations. Although more than one route leads from Szechwan to the Tibetan lands, the best known, the most famous historically, and certainly the most practical is that from Yaan (Yachow) to Tatsienlu *via* Jungking, Hanyüan (Tsingki), and Luting. This is of course part of the official highway from Lhasa to Peiping along which tribute was brought to the Chinese emperors. To-day this is still the most significant commercial route with its ceaseless stream of coolies bearing enormous loads, and the track is known locally as the "Big Road." In the course of two journeys to Tatsienlu and back I had the choice of travelling *via* the "Big," the "New," and the "Small" roads. The first has frequently been described; it is well supplied with rather wretched inns, and food is generally plentiful; and it entails two passes of the order of 9000 feet. The New Road is shorter and has been somewhat favoured by the military; there is only one high pass to cross, but for nearly two days there are no inns and only the rarest habitation. The Small Road is a track that is relatively little known and merits a short description.

The first stage beyond Yaan is Tienchüan, reached by following the Ya valley upstream through Cretaceous sandstones and clays, now through a gorge, now through remarkable erosion terraces often under cultivation. Tienchüan lies on the Mo Shui, a tributary of the Ya. Beyond there neither our coolies nor the local inhabitants knew the second stage of our journey. The local authorities sought to make us change our intentions, return to Yaan, and take the Big Road; but my companion, Baron Conrad van der Bruggen, and I were adamant. In the end we were given a guard of ten soldiers and an officer in command, none of whom knew the route. We followed the Mo Shui upstream, along a practically continuous gorge through the country of the tribal Chiangs. Everywhere the slopes are very steep, and tiny cultivated strips are perched often very high, if it is by chance more level.

It is a well-wooded country, but many forest fires were seen. The first night was spent at Tzu Shih Kuan, the second at Nan Pa Tzu. After crossing a col the new valley entered was found to be equally gorge-like, greatly winding, and cutting into granite. We reached the village of Chang Ho Pa in the afternoon, a derelict place after the passage of the Communists. Beyond here there was virtually no cultivation; the stream flowed in a narrow canyon with overhanging rhododendrons in flower. We spent a night at Meng Kai Shan and followed the route up to the Ma An (Mangan) pass, some 10,000 feet high; here, in the teeth of a fierce wind, we enjoyed a magnificent view of the Great Snowy Range, from Minya Konka northwards. At this height there were



Sketch-map of Sikang and Szechwan to show Mr. Hanson-Lowe's route

but stunted trees and low bush, and broad patches of the winter's snow lay about us. Some four hours' descent took us to the great trench of the Tung valley, and at Luting the Big Road was reached. We bade farewell to our bodyguard and, after reaching Waszekow the following evening, ascended the savage gorge of the Ta the next day to Tatsienlu (Dardsendo), former capital of the independent Tibetan kingdom of Chiala.

Tatsienlu is a cosmopolitan border town, deeply set in the steep valley of the Ta. In the two narrow streets, clinging to the valley wall and in peril of slipping into the fierce waters of the Ta that foam between them, there is the strangest assortment of races: Chiangs, Hsifans, Chinese (many from remote Shensi), Chiala Tibetans, and perhaps tribal Chiarongs. Here is the limit of

coolies' endurance; their enormous packs of tea are carried farther west, to higher altitudes, on the backs of yak, whilst they themselves leave this mountain entrepôt with musk and skins, rhubarb and deers' horns, and other medicines for the millions to the east.

The previous summer I had noted cirques and hanging valleys in the vicinity of Cheto hamlet and Tiju, within a day and a half's journey from Tatsienlu. It had not then been possible to examine them, and a preliminary journey there was the first task. I am much indebted to van der Bruggen for practical help on this occasion. The journey was made on horseback, with a Tibetan guide.

At first the track follows upstream from Tatsienlu, but at Ssumachiao it leaves the Ta and follows a narrow canyon westwards to Cheto hamlet. After the bare slopes we had left behind these steep walls with conifers and scattered rhododendron, wild cherry, birch, and hazel were delightful. From Cheto one looked eastwards to the glaciers of the Tatsienlu peaks; to the south-west one could see the Pilgrims' route that encircles the Konka massif. Two days later we continued westwards to the Cheto pass (Gi La). Long before we reached it, at 14,360 feet, trees and shrubs had been left behind, and the track wound up a stony, barren waste to the deserted cirques where now a little winter snow may sometimes linger. From the pass one looks eastward to the snowy peaks of the Ta Hsüeh Shan; but westwards, 1500 feet below, commences the great rolling plateau of Kham, home of the Tibetan nomads with their millions of yak. On the western horizon the irregular summits of the Sourang range showed where Paan (Batang) lay. The summer before, the west-facing slopes below Cheto had been glorious with alpine flowers; now, after throwing the customary stones on to the labcha at the head of the pass, we descended to Tiju over unlovely turf, hummocky and split by frost.

By the side of the track a heap of stones reminded one of the rest-houses that once were placed along this Imperial highway, but that have not been able to withstand the Revolution, Tibetan uprisings, and the passage of the Communists. At sunset we reached Tiju, a simple inn set in a deep flat-floored valley where azaleas in bloom broke the monotony of the endless grass. We had intended spending the night at the inn, but it was so indescribably filthy—pitch dark inside and full of yak-dung smoke from the fire—that we both decided a night under the stars was preferable. So we fixed ourselves up in the courtyard, just out of reach of the dogs on the one side and the yaks' tongues on the other, for many cattle were herded for the night. Fortunately the temperature did not fall more than half a dozen degrees below freezing. Captain Gill, passing through, thus describes the inn: "Here we halted for breakfast, but it was such a miserable place that we at once passed a unanimous vote for a picnic." [1]

After investigating the local hanging valleys we returned rapidly to Tatsienlu, where I was sorry to take leave of my companion, who was obliged hurriedly to return to the coast. I was most fortunate however in joining forces with Floyd Johnson, who also wished to see something of the plateau. It took nearly three weeks to get sufficient horses and mules to take us and our food. Indeed one wondered, with such an apparent plethora of animals, if the

[1] W. Gill, 'The river of golden sand,' p. 195. (London, 1880.)

Tatsienlu authorities were less favourable to travel in the interior than they smilingly would admit. Fortunately a Tibetan horse-owner owed Johnson a debt. If we used his animals the debt could be partly repaid, and so we were at last able to start. In addition to our tent we had brought provisions of rice, flour, and potatoes for a couple of months. In the larger settlements yak tongues, beef, and liver were often obtainable, but to get mutton it was apparently necessary to purchase the whole animal. Yak butter was easy to get, but it was rarely fresh and of the hirsute variety. Yak milk was available, but at times was difficult to obtain since some of the nomads believed that their animals would become diseased if their milk were given to foreigners. Where Chinese influence was marked chicken and eggs were to be had, but the eggs varied in price and quality, and would frequently rattle when shaken. Potatoes were sometimes obtainable, and we were able to lay in a good stock of imported sugar and peanuts at Lihwa. For cooking a pressure-cooker is essential, unless you wish to wait four hours for a stew and as many for a bowl of rice. There is plenty of fuel in the deep gorges, but on the plateau there is only dried yak dung.

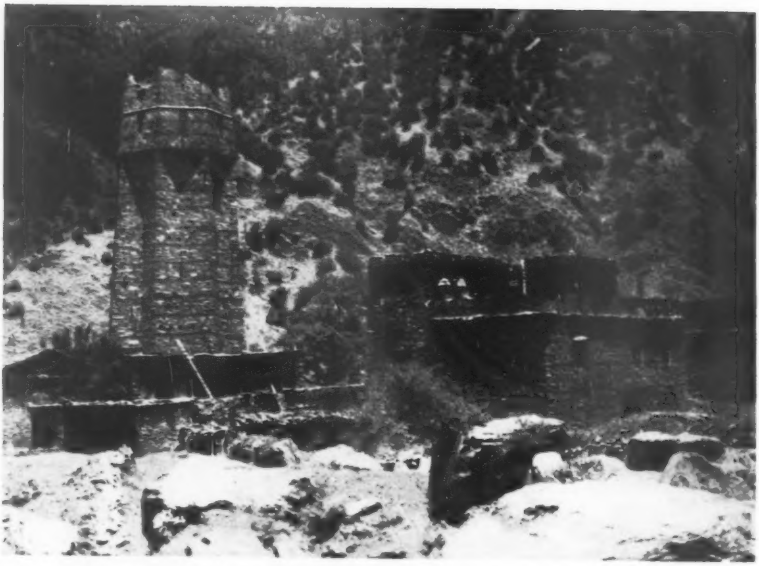
Chinese currency is valueless except at the few post-offices maintained by the Chinese, and purchase is by barter or the rupee, then worth about 6½*d*. As there is no coin of less value than the silver rupee, the Tibetan has no hesitation in cutting one in halves. For the foreigner not out to barter, the marketing question resolves itself into how much can be bought for a rupee, rather than into how much must be given for a certain amount.

Once the stone bridge above Tatsienlu was crossed we were in territory where Chinese are few and where the nomad and lama are almost the sole folk met with; ethnologically the boundary with Tibet is the Tung river. Camp was pitched at Cheto: the night was perfect, with the Tatsienlu peaks showing faintly in the light of an early moon. From Cheto we again reached Tiju, where we camped for the night, and so continued for two days to a camping-place not far below the summit of the Kaji La, *via* Nawashi, Yingkwanchai and Tongolo, and past scattered Tibetan dwellings and fewer trees, wild gooseberry bushes and startled marmots, solitary chörten and despoiled dumps of auriferous gravels. From the Kaji La (14,890 feet) there should be a magnificent panorama, to the north-east and south-east, of snowy peaks from Jara to Minya Konka; but clouds hid the horizon, and shortly afterwards it began to snow. As it did so a Tibetan rode towards us over the pass, with rifle and mail-bag, singing gaily. His song had the wide, leaping intervals characteristic of Tibetan melody, in which, although a diatonic flavour is apparent, the final note, prolonged for several seconds, seems quite unrelated in key.

Beyond the pass the route led into a deeply incised valley, first through a rhododendron zone and, lower down, into magnificent spruce forest with lovely cones of maroon or mist-veiled indigo. Where fire had destroyed the spruce birch tended to replace it. Lower down came sycamores and ilex. At 12,140 feet patches of cultivation were seen, with barley, oats, and potatoes. Wild roses were common and tiny orchids abounded. After camping for the night we continued downstream; the valley walls, still very steep, were now bare and dry, with coarse grass and low, sparse bushes. These conditions

Tatsienlu

Loading yaks with tea at Tatsienlu



Tibetan house and defence tower near Yakiang

Disembarking on the west bank of the Yülung at Yakiang

extended to the junction with the great Yülung river at Yakiang (Hokow or Nyagika). In parenthesis it may be mentioned that the above vegetation zones are characteristic of all the deep valleys I traversed.

Yakiang clings to a ledge on the rocky walls of the Yülung gorge, almost slipping into the turbulent waters. Here we pitched our tent on a pebble-and-boulder beach, and spent a good deal of the night trying to keep it up in a fierce wind that rushed through the canyon. The next morning men, baggage, horses, and mules crossed the Yülung, a passage that has its risks, since a few days later this very boat sank in the rapids, all but two being drowned. We were now accompanied by two Tibetan guards armed against robbers, who are quite common in Kham. They wanted, once we were well away from Yakiang, to have the whole of their fee immediately. This was rather awkward, since we did not know how far they were to be trusted. Boldly we advanced a portion only, and there was no more trouble.

The route led up a forested valley where we camped for the night; the upper part of the valley was almost wholly in grass: we had again reached the plateau. We crossed the Rama La (14,920 feet), and after many miles of rolling upland again descended to Singolo, a tiny hamlet in a broad, flat-floored valley. The next morning it was necessary to exchange our guards for others from the local Tibetan chieftain, or *Tu Se*.

His fortress was impressive: a great three-storied building of stone and wood, with minute windows, and flanked by numerous chörten. Entering the gate we first crossed an untidy courtyard wild with murderous Tibetan dogs which, like their Mongolian brethren, will tear your throat out if you venture on their master's premises, and yet will slink away with tails between their legs when met with in the street. Passing in darkness through the stables we climbed rough stairs to the granary, and then up further steps to a narrow landing overlooking a square central space open to the sky. We were ushered into a great hall whose roof was supported by immense pillars of spruce. Here it was very dark, smoke-filled, and lit by the flames from a great stove set against the outer wall. On the wooden partition wall rude figures were carved and painted, chörten, swastikas, etc. Along the walls a continuous bench was placed, roughly upholstered, whilst before it was an equally long and narrow table in which, at intervals, were depressions containing shallow pans with charcoal fires used for keeping the tea hot. The tea itself was prepared at the great stove, opposite which was a second one, equally big but not then in use. On the low table were numerous piles of tsamba and butter for guests and inmates of the fortress. The *Tu Se* greeted us and showed us to the long seat. He was a tall, striking man, rather handsome and with long uncombed hair, dressed in a bluish-purple Tibetan cloak, high Tibetan boots, and girdled by a belt from which the inevitable knife and tinder-pouch were hanging. He wore immense rings on his fingers with stones of red coral and pale blue turquoise; from his ears hung others equally big.

We were offered buttered tea and tsamba, and in our turn offered a cloth-bound book, printed in Tibetan at Shanghai, and with endless illustrations, many in colour. With this he was obviously delighted. A few moments later we were groping our way through the smoke, past glimmering ladles of brass

that hung in great numbers on the wall, and so into the brilliance of the morning sunshine. The chief accompanied us to the very gate, smiling and indicating a stalwart guard of three.

The normal route to Lihwa (Litang) was dangerous on account of the banditry for which Kham is famed. We took a slightly longer way and after two days' travel over the grasslands reached one of the highest settlements in the world, and pitched camp near the yamen at 13,440 feet above sea-level. Lihwa lies on a sandstone spur above an elongated plain several kilometres broad, on the opposite side of which rise low granite mountains once glaciated. The essential Lihwa is the lamasery with its 3700 lamas and drabas. The town consists of a single line of hovels stretching down the spur and sheltering some 750 inhabitants. Below the town lie the ruins of a great fortress that belonged to the princes of Litang. A more unpleasant locality for a settlement would be hard to find, with the treeless, often bare, landscape, the amazingly rapid temperature changes, the high winds and dust, the frequent lashing hail in summer and the exacerbating effects of high altitude. The inhabitants throw their refuse out of the back door so that the town is almost completely surrounded by garbage dumps, which the 24th Army was endeavouring to beautify by constructing walks and pleasances upon them. This part of Tibet is nominally under Chinese control, and the town has a Chinese garrison and magistrate. But control is not easy, and a state of compromise actually exists. For this reason we found it most difficult to get northwards from Lihwa, the magistrate doing his best to persuade us to return to Tatsienlu. Two powerful *Tu Se* held sway between Lihwa and Chantui (Chanhoa); if a Chinese guard were sent with us we should all certainly be robbed and probably lose our lives. He pointed out that a Chinese magistrate was forced to make friends with the strongest of the local *Tu Se* and so enjoyed very strictly limited power. Even the Reincarnation at the Lamasery could give no guarantee of safe passage. Neither of us carried any firearms whatsoever, and the only solution was to get into touch with the *Tu Se* and arrange to pay them tribute, if they would take it, in return for safe convoy. This caused much delay but gave us time to see the town and locality.

The lamasery, built of wood and stone with cupolas of gold, and with its weather-beaten prayer-flags, dingy halls of worship with faded images and banners, prayer-wheels, its all-pervading odour of rancid butter, and its inmates themselves in their filthy red robes, certainly enthralls the imagination. Although hated by the valley farmers and nomads the lamas control Tibet, and they are so suspicious of foreigners, and so conservative, that the smallest degree of modernization would seem impossible. Early in the day they pray and meditate; afterwards they stroll about in little groups, buying and selling horses, or doing other trading.

Fortunately we were invited to meet the head Lama, known to the western world as a Living Buddha. Crossing the courtyard, we were shown up a rough and rickety stairway with a loose yak-hair rope for banisters, and so along a dark passage-way into a gloomy chamber. We could make out the form of a Tibetan rising to greet us, and were motioned to sit on his left hand on a fine leopard skin spread on a long low seat with table and small brasier before it. We were offered aromatic tea in porcelain cups set on attractive

metal stands, fruit, and candied sugar. The Lama was a tall handsome man, some twenty-five years old, and sat with his back to a tiny window cross-legged on a pile of cushions. On the table before him juniper incense rose from a small censer set amid a clutter of books and writing materials. On the opposite side of the room a species of sideboard supported a central Laughing Buddha and a host of smaller effigies. On our host's left hand were more figures, two old-fashioned western clocks with glass sides, and six electric torches. On one wall hung numerous photographs of officials and lama dignitaries, and two large Chinese posters, one of Sun Yat-Sen, the other of Chiang Kai-Shek. Tibetan knives, a belt, and riding whips hung from a central wooden pillar. Lastly, in front of the small window facing us an inquisitive crowd of dim, peering forms were observing us. Our headman spoke to the Lama in Tibetan and translated his replies into Chinese; but both of us had the impression that the Lama could speak Chinese himself. He apologized for not inviting us to eat with him on the grounds that we should find the food unpalatable, but made us a present of sugar and dried jujubes, promising to send milk and eggs in the morning. He was then presented with illustrated books, and graciously gave us permission to photograph him. This was done the following morning; the courtyard having been emptied of the curious, a fine rug was spread there, with seat and leopard skin, and the Lama descended.

The local Chinese garrison was commanded by a very charming officer. We noted that, at a feast offered us at the yamen, he refused meat and wine. In the lamasery he had filled a whole chapel with lamps—wicks floating in melted yak butter—and symbolic mounds of buttered tsamba. At his quarters figures of Buddha hardly left room for a bowl of tea. Such extreme piety seemed to demand an explanation. Actually, he was making his position safer with the Lama by showing the religious excellences of which he was capable; he had certainly not forgotten that a large detachment of Chinese soldiers was then on its way to Lihwa. The arrival of these soldiers the night before we left was followed by fighting between the Tibetans and Chinese.

From Lihwa our route led northwards; following our Tibetan guards we travelled over the grasslands, now in a deep valley where gold-washing was in progress, now over a high pass. The first *Tu Se* to whom tribute was due lived in a small settlement not far from the head of a deeply incised tributary of the Yülung. He was the proud possessor of a western bed, a witness to the wrecked and plundered missionary hospital at Paan. He was most anxious that his photograph be taken, seated on his bed and surrounded by specimens of Victorian cheap glassware and pottery. Guards were exchanged and we set off in the morning down the same valley, thick with spruce and gay with wild flowers. A few strips of cultivation were seen, with barley growing, at 12,570 feet. That evening, after passing an enormous manidrombo, at least some 300 yards long, we reached Hsü Hsi Sung Tu, with its large fortress. After a vicious downpour of hail we camped, and were visited by the local *Tu Se*. He was a saturnine individual who, sitting gravely in our tent, suddenly produced an alarm clock from his gown. This looked like a feat of prestidigitation, to impress us; actually, the

alarm refused to function. My companion soon fixed it. Without uttering a word in reply the *Tu Se* produced just as suddenly a small musical-box, which also refused to perform. This was more of a problem to mend, but in twenty minutes we heard a crystal tinkling, and a charming Gallic melody filled the tent. To this *Tu Se* the second lot of tribute money was due, and we visited him at the fortress the next morning. A large and highly ornamental oriental clock boldly faced us as we entered the private apartments, a sight that made my companion blench slightly, but fortunately it was only there to be admired.

Later we reached the Yülung again, true daughter of the turbid Yangtze, and here incised many thousands of feet. A few miles farther up it was to be crossed by yak-skin coracle. The horses had to swim, being pelted with stones until they did, whilst we swept downstream at a good 20 miles an hour to Ma Hsü. The next morning we passed up the steepest tributary we had yet encountered and soon struck woodland, gay with wild roses, elderberry, wild cherry, and countless varieties of wild flowers. At the head of this long pull we passed through a forest of matted and tangled ilex from whose branches hung masses of grey-green moss. At last the grasslands were again reached, but not without the loss of our white horse, henceforward incapable of bearing a load. That night we camped at 14,980 feet; in a valley far below us great herds of yak pasturing looked like a battalion of strange beetles.

The next afternoon we crossed the Sara La (16,100 feet). Our men were on their knees and, we thought, praying to the deities of the mountain; actually they were gathering wild onions that abounded there. Glorious yellow *Meconopsis* grew too about these once glaciated highlands. After a short but lashing downpour of hail we entered a further deeply incised tributary of the Yülung, and camped shortly after the spruce belt had been entered. The hail and thunderstorms we encountered during the whole journey were many. At Lihwa the wind one night of storm had been so great that our tent, in spite of all our efforts, had been blown over our heads.

Crossing a Tibetan cantilever bridge over the Yülung, the next afternoon, we reached Chantui (Chanhwa), and camped under the ruins of the great fortress. After lunching with the magistrate we watched Tibetan women dancing. The dancers formed two semicircles each moving independently in a ring, so that one semicircle would pass the other at intervals. As they moved they made intricate foot and arm movements, waving ceremonial *katas* (silk strips), but never making abrupt movements. They sang a song with a great number of verses with a strongly modal flavour. The wide intervals were not so marked, but the long pauses on final notes were again characteristic.

Our route now led up the Yülung itself. The strain of the journey was beginning to tell on the mules, and we applied for *ula*. This system of animal hire, instituted in Tibet in Imperial times, was originally intended for officials. Now it has fallen into abuse and its granting depends on the whim of the local authorities. The original idea was that the Tibetans should supply animals and, in return, a small sum of money was given them, although the greater part of the fee took the form of a remission of part of the taxes. At first this system caused us much delay; at the end of each stage, sometimes only a few

Jara

The Yülung gorge below Ma Hsü

The lamasery at Kantse

Tibetans in the main street of Lihwa

miles, the ula-owner would be away, or would have to chase after his animals, or even we should have to be content with riding yaks, with a single rope through their noses as a rein. At times there were no animals available and we had to wait till there were (no one was willing to lose a chance of tax remission), and the discussions hindered and irritated us. On the third day things improved and we had not to change more than twice a day.

Very striking high-level erosion terraces are to be seen in this part of the Yülung as well as low-level aggradational terraces. At Cha Na the Tibetans sought to prevent us from camping at what seemed an excellent spot, saying that an evil spirit lived there: when the tent pegs were driven in he would awake and we should be stricken with illness. Actually the place was very marshy and not unlikely to give rheumatism to those who stayed long.

At Takai there is a large lamasery. Here we found it much cooler, being not so far from the beautiful snow-clad summit of Ka Wa Lu Jih and its attendant peaks. Highly religious lamas are able to observe a black lion that at times chases around the peak. Two days later we reached Kantse. The Yülung gorge had been left at noon, and the route led across a level plain, rather broad, with the braided Yülung clinging to the southern edge. In the distance to the south-west were snow-clad limestone mountains. Camp was pitched at 11,430 feet in a little grove below the lamasery. Here there are some two thousand lamas and drabas, but in spite of the outwardly attractive appearance of the lamasery, with its flat roofs so reminiscent of Algiers, and its golden spires, the interior is extremely shabby and dirty. The place is a gigantic rabbit-warren of filthy, muddy passage-ways, dog haunted, off which small doors lead into the lamas' quarters. In a small courtyard a couple of lamas were practising some steps for the devil-dances; Tibetan women were bearing great wooden pitchers of water; tattered and discoloured prayer-flags hung in a motionless air. The town is fairly clean since the Chinese have brought their New Life Movement here. There are some fifty or sixty Chinese families and some four hundred and forty-five Tibetan ones. The magistrate invited us to an *al fresco* luncheon in our little grove, although it is most unusual for the Chinese to eat in the open, especially at a feast.

After a few days at Kantse we left for Taofu. At first the route led eastwards across the treeless plain where thousands of little tailless rats scampered before our mules and where peonies were numerous. In a deluge of rain and sleet we crossed the Lukwo Liangtze pass and so down towards Ka Sha lamasery, wall-girt, beside a little lake. Here cultivation started, and there were fields of barley, peas, and mustard for oil. After camping at Chuwo we followed the Lu river downstream for three days. This is gorge-like only in sections, and bears no resemblance to the great Yülung. A twelve and a half hours' stage was made to Luhwo, where a great lamasery lies 1000 feet above the river. The chief lama there is a man of progressive tendencies and, according to local talk, would like to leave his position and take up a western type of life. The Chinese are restraining him owing to his political and administrative capabilities. Some way below Luhwo the valley broadens out and the river flows in a braided course. From here as far as the Taofu region, and even to Taining, striking earthquake rents are seen everywhere, memorials

of the great quake of 1918 and of the even more disastrous one in 1923. A further point of interest is that here, as well as at Kantse, loess is much in evidence, at times *in situ* but more often rewashed, or otherwise *remanié*. Calcareous concretions were found in the loess at Kantse.

Again the valley narrowed to a gorge and once more widening somewhat led to Taofu, 10,200 feet above the sea. Here we were the guests of Father Doublet, who for years has been in charge of this outpost of the Catholic Church. The passage of the Communists had scourged the country; thousands of Tibetans, tribespeople, and Chinese had been butchered; settlements were burnt and all food eaten. Naturally, there were no crops in 1936 and famine was rampant. In the tribal areas of Hsiu Chin, Tanpa, and Mongkong conditions forced the natives to cannibalism.

From Taofu to Taining is normally two stages, but it was not possible to stay the night at Kwan Chai Tzu owing to the bandits which then infested that halfway halt. We therefore did an easy stage the first day and a gruelling one the second. Until 9 a.m. on the second day, when the Sunglingkow pass was crossed at 13,280 feet, we ascended a wooded valley. Spruce and scrub ilex were common, and wild roses, strawberries, and wild currant bushes gave variety. It is worth mentioning that the present topography, in the region traversed, makes for the greatest contrasts in insolation, exposure to wind, duration of snow-cover, amount of precipitation, rapidity of run-off, etc., in areas separated from each other often by a few tens of metres. These contrasts are clearly marked in the vegetation: one side of a valley, usually that facing north, will be clad with magnificent conifers; at the same elevation, but on the opposite side, there will probably be but scattered ilex. But let the valley change, even temporarily, its direction, and the vegetation types reverse sides.

On the second day after leaving Taofu the watershed between the Tung and Yülung rivers was crossed, an area with great earthquake cracks, and Taining was reached. Shortly before reaching this settlement a magnificent evening view of the Minya Konka complex was enjoyed, the great mountain rising on the south-eastern horizon, whilst right ahead of us, very near, was the snowy glory of Jara. Well before noon the next day a pass of no great height was crossed and, after much delay, for the Tibetans had let the horses stray out of sight during the lunch halt, we reached a well-incised valley, timbered with conifers, birch, and ilex, and flowing from the direction of Jara. Further up this valley a perfect terminal moraine was examined at a height of 12,430 feet. High up numerous small corries were seen. Both features belong to a past glaciation, and the whole question of Pleistocene glaciation will be treated in a separate paper. Camp was pitched only a few kilometres from Jara, in a little wood and, the next morning, after investigating the local moraines, the steepish ascent was made to the Haitzu pass at 14,038 feet, beside Jara itself. On our right was an enormous morainic bank sheltering a small but beautiful bluish-green lake fed by a waterfall from the melting ice above. The route led past the mound, and after a stiff climb one reached an upland whose level nature was disturbed by the great morainic piles strewn about. All around were bare, glacially dissected summits, but snow and ice were observed on Jara alone. On the flattish upland two further

lakes were passed and, once over the Haitzu, through a zone of sparse azaleas and rhododendrons, the route led into a remarkably rectilinear valley, once glaciated. From there, past the hot springs of Chungku and Erh Tao Chiao, it took not much more than a day's travel to reach Tatsienlu once more. The first signs of cultivation were at Chungku, at 10,600 feet. At Erh Tao Chiao (*c.* 8000 feet) cultivation was varied; its crops can include wheat, barley, oats, cabbage, beans, peas, carrots, turnips, celery, even maize, buckwheat, and potatoes. Here moreover, on account of the sulphurous hot springs, the inhabitants of Tatsienlu have constructed a rough road to the hamlet, making it into a small spa. All day long the good folk of Tatsienlu were coming and going, the majority on foot, the wealthy in one of those three or four rickshaws so very recently arrived and still the wonder of the town, this little strip of road being the only place for miles where a rickshaw could travel.

Note on the sketch-map, p. 358.

The author's route as shown in the sketch-map is based on the work of H. C. Tan and C. Y. Lee, with additions, including heights, by the author. The rest of the map follows the New China Atlas, 1936.

NOTES ON THE BARROW COLLECTION OF ARCTIC EQUIPMENT

BRIAN ROBERTS

SIR JOHN BARROW, one of the founders of the R.G.S., was born in 1764 and died in 1848. He served as Second Secretary of the Admiralty between 1804 and 1845, and during that time did much to further Arctic exploration. Sir John had four sons, the second of whom, John (1808–98), followed his father to the Admiralty and became Keeper of the Records. He has frequently been confused with his father by subsequent writers and even by some of his contemporaries. He served in the Admiralty from 1825 to 1857, and during this time acquired his father's interest in Arctic exploration; probably he contributed to the results more than any other man not actually employed on the expeditions. The leaders of these expeditions, "having received much personal attention from Col. Barrow, one and all felt desirous of evincing their esteem for him by bringing home some memorial of the places they visited, and which they knew would be interesting to him." [1]

Thus came into being a valuable collection of objects illustrating both the material culture of the Eskimo and the equipment of British Arctic explorers of the period. The younger Barrow was an enthusiastic correspondent with all his Arctic friends, and a large number of their letters are preserved in the British Museum Library.[2] These letters are from officers of all ranks and from civilians who took part in the various Arctic expeditions in search of Sir John Franklin. Most of them were written during Colonel Barrow's official connection with the Admiralty, but they are all addressed to him in his private capacity and many are of a confidential nature. Almost all of them pour out thanks for Colonel Barrow's kind attentions to the writers and to their families in their absence. A typical one, from Robert Anderson of H.M.S. *Enterprise*, dated 20 May 1855, runs: "All the officers appreciate well the kind interest you have taken in them when they were away and sequestered from the world. . . . I understand you have an Arctic Collection in your family. If you have any gaps which I can fill up I shall be most happy to send you anything I possess. Please have no hesitation in naming whatever you want." The collection was exhibited at Ulverstone in Lancashire (Barrow's native town), and later at the Royal Polytechnic Institution in London. In 1855 it was presented to the Ethnographic Department of the British Museum. The collection thus transferred contained 624 items which were later catalogued by W. Parker Snow. Thirty-six of these items were personal relics of the exploring expeditions, and, not being of special ethnographic interest, these have recently been passed on to the R.G.S., where they are now on exhibition.

The present notes are intended as a catalogue of this smaller collection which is mainly composed of scale models illustrating the detail of early

[1] W. Parker Snow, 'A catalogue of the Arctic Collection in the British Museum . . .' London, 1858. [Copy in the Ethnographic Department of the British Museum, interleaved with MS. additions.]

[2] Add. MS. 35306–35309. Letters from Arctic explorers to Col. John Barrow (son of Sir John), Keeper of the Records of the Admiralty. Bequeathed by him to the British Museum in 1899.

specialized equipment. Each model is marked with a British Museum registration number, and from these and Snow's notes it has been possible to identify most of the items.

The following expeditions are represented:

Hecla (Parry), 1827. Summer cruise to Spitsbergen in an attempt to reach the Pole.

Lady Franklin (Penny) and *Sophia* (Stewart), 1850–51. Franklin search. Wintered in Assistance Bay, Cornwallis Island.

Pioneer (Osborn), 1850–51. Franklin search. Wintered off Griffith Island.

Resolute (Kellett) and *Intrepid* (M'Clintock), 1852–54. Franklin search. First winter at Dealy Island (Melville Island). Second winter in the pack. Both were abandoned in 1854.

North Star (Pullen), 1852–54. Franklin search. Wintered at Beechey Island.

Pioneer (Osborn), 1852–54. Franklin search. First winter in Northumberland Sound. Second winter in Wellington Channel. Abandoned in 1854.

The last four of these ships were in the squadron under the orders of Sir Edward Belcher.

Students of the evolution of Arctic technique will appreciate more fully the value of this section of the Barrow Collection if they compare it with the Arctic exhibits in the National Maritime Museum at Greenwich and with the collections of equipment at the Scott Polar Research Institute, Cambridge. No adequate survey of the evolution of polar technique has ever been made. Yet without an understanding of the equipment and methods employed by the early explorers, it is impossible to pass fair judgment on the work which they accomplished. For this reason I have added a few general notes on the equipment of this period, together with extracts from journals and reports describing its use. In the list which follows, the original B.M. registration numbers have been retained.

Before considering the equipment used on a sledge journey, a word as to the type of man selected to haul the sledges. Writing in November 1851, Mr. Bradford, Surgeon of H.M.S. *Resolute*, made the following comments to the Arctic Committee [1]:

"Too much importance cannot be attached to the duty of selecting the men to compose the party. They ought to be strong and robust, ruddy complexioned, with a good and full chest, perfectly sound in their wind, flat and well muscled about the loins, with good buttocks and strong muscular thighs. Having the men of nearly the same height is favourable to the effort in dragging being simultaneous. Tall long-legged men stow badly in the tent and frequently are not so capable of long-continued fatigue as those of a shorter stature and more compact form. Five feet seven inches and a half to five feet eight or nine inches is a height that frequently combines great strength and power of endurance with a sufficient length of limb to admit of free action. The very short-legged heavy-bodied man ought not to be selected as he soon becomes exhausted in deep snow by his struggles to clear his legs. The age may vary between twenty-five and thirty-five years. Temper is not to be overlooked, as an irritable man, under the privations and hardships of a lengthened journey, is certain to break out, and be a constant source of annoyance and irritation to his more patient neighbours, both on the drag-rope and in the tent.

[1] *Report of the Committee appointed by the Lords Commissioners of the Admiralty to enquire into and report on the recent Arctic Expeditions in search of Sir John Franklin.* H.M. Stationery Office ,1852. Enclosure No. 15.

The true thorough-bred man-of-war's man or royal marine I should select in preference to any others, as they never think of having an interest, in cases of difficulty, at variance with that of their officer, whereas the merchant-seaman is apt on such occasions to think of himself. Stewards, idlers whose duties have confined them much below, and men who have led debauched lives, ought not to be selected for lengthened travelling, as it will be found on trial that after a few days they either shrink from their fair proportion of work, or else break down."

Sledges

The sledges used by the Royal Navy at this time were made of wood, of different sizes. Their method of construction was the subject of much discussion. Belcher seems to have been the first to recommend that the runners be shod with steel, but probably M'Clintock did more than any one else of the period to improve the design and method of packing. The Barrow Collection contains nine models of typical designs:

111. *Her Majesty's Sledge "John Barrow"*—Commanded by Sherard Osborn, H.M.S. *Pioneer*, 1852–54. Model: 21·5 inches long; scale: 2 inches to 1 foot, fully loaded, and complete with drag ropes. "Presented to John Barrow by the crew of the sledge." The full cargo of this sledge, as ordered by Captain Sir Edward Belcher for a long journey, is listed as follows: [1]

	Weight, lb.
Sledge and ropes with strong canvass bottom	120
Forster's patent sledge boat	24
1 Waterproof and 1 Duck cloth (floor)	36
1 Tent (8 men) and ropes, bow-lines, etc.	37
1 Felt robe	25½
1 Fur robe (Buffalo)	39
2 Cooking apparatuses (one being a spare one)	40
Store bag	18
Medicine case (tin)	10
1 Shovel	4½
1 Pickaxe	10
Officers' instruments, sextant, thermometer, artificial horizon, note book, telescope	10
2 Cooks' knives	1½
4 Tent poles, and 1 pike spare	21
1 Boat-hook staff	3
2 Bamboos	10
8 Knapsacks, allowing each man 7 lb. for spare clothing	56
1 Gun and gear with spare ammunition	36
Luncheon haversack with spoons, pannikins, and daily rum can	8
Small axe, etc., such as candles	7½
Eight sleeping bags	56
Total dead weight	557
Provisions and fuel, 40 days	783
Cans and packages	60
Total	1400

"This dragged by seven men gives 200 lb. each, with a daily reduction of 22 lb. 11¾ oz. for food, which however was completed constantly by supporting sledges."

[1] *Further papers relative to the recent Arctic Expeditions in search of Sir John Franklin . . .*, p. 185. H.M. Stationery Office, 1855.

112. *Her Majesty's Sledge "Star of the North"*—Commanded by F. L. M'Clintock, H.M.S. *Intrepid*, 1852–54. Scale model as No. 111, with canvas container and drag ropes but no cargo. This sledge was employed in the search for Franklin to the north-west of Hecla and Griper Bay in 1853. The weight at starting was 2280 lb. with 53 days' provisions. Abstract from Captain M'Clintock's Journal[1]:

"105 days absent. 1030 geographical miles travelled in 99 marches.

860·6 hours travelled. 1403 hours rested. 44·3 hours lunched. 167·2 hours detained by weather. 49·1 hours about cairns, depots, etc.

Average distance marched—10·4 geog. miles.

Average time marched—8·7 hours.

Extent of coast discovered and searched, commencing from Point Nias—768 geog. miles."

113. "*Satellite Sledge.*" Model 13 inches long; scale 2 inches to 1 foot. This type of sledge carried a week's provisions for an officer and two men.

114, 115, 116. *Sledges used by Captain Penny's Expedition*, 1850–51. Models 12, 12, and 10 inches long respectively. All three are similar in design but have different numbers of deck boards. These are hard-runner sledges of simple design without handlebars.

117. *Sledge used by Captain Penny's Expedition*, 1850–51. Model 10 inches long; packed for travelling. Design as above but with handlebars. Fitted with drag ropes and shoulder loops for seven men.

119. *Dog sledge used by Captain Penny's Expedition*, 1850–51. Model 11 inches long, with handlebars.

120. *Dog sledge used by Captain Penny's Expedition*, 1850–51. Model as above, complete with harnesses for ten dogs. These last two sledges are of the type still used by the Eskimo of West Greenland.

121. *Model of Sledge crossing Hummocky Ice.* "To illustrate the labours of Arctic travelling." Seven figures dragging a sledge. Model $11 \times 5\frac{1}{4}$ inches. Presented by Lieutenant Bedford Pim, lieutenant in H.M.S. *Resolute* (Kellett), 1852–54.

For man-hauling units the sledge loads were usually calculated not to exceed 210 lb. per man. Dogs were tried, but on very hummocky ice the difficulty of working the sledge with them was found to be so great that they were only used as auxiliaries and on special occasions. They were employed with sledges of different sizes and in teams varying from two to eight dogs. A good example of their value in an emergency was shown in June 1854, when a seven-dog sledge brought Captain Kellett, who was ill, from the *Resolute* to the *Assistance*, 150 miles, in twenty-four hours.

Captain Sherard Osborn gives the following description of the sledges used by him in 1850–51[2]: "Constructed of tough and well-seasoned wood, they had been carefully made in Woolwich Dockyard. They were shod with iron, and the cross-bars or battens which connected the two runners, and formed the floor upon which the load was placed, were lashed in their places by us when required for use. At the four corners of the sledges light iron stanchions dropped into sockets, and formed the support for the sides of a species of

[1] *Further papers . . .*, p. 585.

[2] Sherard Osborn, 'Stray leaves from an Arctic Journal,' p. 195. London, 1852.

tray or boat, capable of serving to ferry the sledge crew across water in an emergency, as well as to keep the provisions and clothing in it dry. This boat was made in some cases of gutta-percha, in others of oiled canvass;

	lb.
And, together with the sledge and drag-ropes, which were made of horsehair, to prevent their becoming hard and brittle from frost, weighed	120
Two fur blankets and spare blanket, two weighed	40
Nine blanket-bags for sleeping in	42
A tent of oblong form, made of a species of brown holland, supported by four boarding-pikes, and a line which served as a ridge-rope, and was set up to any heavy thing that came to hand	55
Mackintosh floor-cloth to spread over the snow or gravel	12
A shovel to dig out snow for banking-up with	5½
A cooking apparatus, invented by Lieut. M'Clintock, capable of cooking a pint apiece of tea, cocoa, or pemmican, with a spirit lamp, tallow lamp, and spare kettle	17
Sextant, 1 gun, and gear	10
A bag containing 5 tin pannikins and 5 spoons	5
A knapsack for each man, containing 1 flannel shirt, 1 Guernsey frock, 1 serge frock, 1 pair of drawers, flannel, 1 pair of boot hose, 1 pair of stockings, 2 pairs of blanket-socks, 1 towel, 1 comb, 1 lb. soap	48
Spare boots, and thick Guernsey frocks for sleeping in	36
A *tin case*, containing pepper, salt, herbs dried, lucifer matches, grog-measure, calico and flannel bandages, plaster adhesive, lint, liniment, eye-wash, pills, simple ointment, glycerine, lancet, tincture of opium, pins, needles, and thread	16
Store-bag, containing broom or brush for sweeping the tent down with, spare boot soles, wax, bristles, twine, shoe-tacks, crape awls, slow-match, nettle stuff, and strips of hide, cylinders for documents, printed records	11
Spare ammunition, cleaning rods, and wrench	14
Kites and string	12½
Dead weight, lb.	440

The complete load of such a sledge for a long journey was recorded as follows[1]:

	lb.
Total dead weight	440
Pemmican and cases	330
Biscuit and dust, etc.	278
Pork and packages	123
Tea, sugar, chocolate, tobacco, etc., in a case	47
Lime-juice and rum	67
Spirits of wine and tallow	78
Sundries, tins, etc.	45
	1408

Number of men to drag 7. 201 lb. per man.

"The officer's load consisted of a gun, powder and ball, telescope, compass, and note-book; and as all the party, in anticipation of cold weather, had to be heavily clad, it may be supposed that the total weight to be dragged through snow and over rough ice was quite as much as the stoutest physical powers were capable of."

In a letter to the Secretary of the Admiralty, dated 9 December 1851, Captain Austin of H.M.S. *Resolute* gives a more detailed inventory for a party

[1] Sherard Osborn, *op. cit.*, p. 198.

1. Capt. Richards' party bringing Pioneer's ice-boat from Melville Island

Illustrated London News

2. The North Pole Expedition: a sledge party camping for the night

3. Man-hauling the boats on sledges

4. Cutting a passage with an ice-triangle

of eight persons.[1] The equipment which he recommended is the same as that used by Captain Penny:

1 Runner sledge with white hemp drag-ropes, hide-lashings and two spare cross bars.	Of the length of the longest in the late expedition, and with rather more curve of the runners; the iron shoeing of the best wrought metal, strongly and carefully riveted, instead of screws.
1 Light canvass trough	Coated with oil, or some other preparation to make it watertight bearing in mind its tendency to crack from extreme cold.
1 Tent	As in the last expedition, but a little larger, and doubled about 1½ feet from the ground at its windward end, the lower part increased by a small goring, the upper part remaining as at present.
5 Pikes	One fitted with a small ice chisel; points covered with leather sheaths before leaving England.
1 Floor-cloth; fitted also as a sail ..	Light; of some prepared material that is watertight and will not crack from extreme cold (a dark surface preferred).
2 Buffalo robes	Being superior for this service to wolf-skins selected specially and rendered as strong as possible large enough to turn over a foot at each end of the tent.
1 Cooking apparatus in fearnaught cover, with a light strong tinder-box.	Of copper, with copper rivits, copper spirit and tallow lamps; stew-pans and a little larger than those in the last expedition. The introduction of wicks in the spirit lamp should, if possible, be simplified, as also the means for extinguishing the lights; one cover to the whole lamp, if practicable, instead of one to each wick.
1 Cooking apparatus for tallow ..	Of simple construction; for extended parties only.
1 Haversack for luncheon	Of duck; light and strong as can be.
1 Lead (and about fifty fathoms of small line).	For sounding, etc.
1 Store bag	Of duck; to contain sail-needles, eight spare soles, twine, a few common needles, thread, two pairs of spectacles (neutral tint), two yards green crape, two yards No. 4 canvass, two awls, shoe-tacks, skein of marline, two palms, boxes of matches, slow match, spare wicks for tallow lamp, one small chisel, one hammer, one strong coir tent-brush, one clothes brush, wax bristles.
2 Double-barrelled guns. 6 lb. ball. 10 lb. shot, Nos. 1 and 4.	Also cleaning rod, two spare nipples, nipple screw, and turn-screw.
3 lb. powder. 500 Percussion caps.	

[1] *Further correspondence and proceedings connected with the Arctic Expedition*, p. 107. H.M. Stationery Office, 1852.

1000 Wads.	
2 Shot pouches.	
2 Powder flasks.	
1 Lantern	Of small dimensions, and of as light material as can be for standing wear and tear.
1 lb. short wax candles.	
200 Small brimstone cotton matches ..	In a light tin case for security.
1 Iron shovel	Made as strong as can be.
2 Measures, 4 gills and 1 gill	Made of copper.
50 Gutta percha cases and small printed notices for depositing.	
Instruments for observations:	
1 Telescope.	
1 Artificial horizon.	
1 Kater's compass.	
1 Compass (small).	
1 Tripod stand for compass.	
2 Pocket chronometers.	
1 Small thermometer in case.	
1 Outline chart.	
1 Note book.	
1 Case of medicines, etc.	In a tin case, specially prepared in England.
1 Small Bible and Prayer Book.	
2 Hand towels.	
1 lb. Soap.	
1 Felt sleeping-bag, each person ..	Seven feet in length.
1 Duck haversack for officer	Made in England; light as can be.
1 Duck haversack each man	Made in England; light as can be; not too limited in size.
1 Wooden pannikin, 1 wooden spoon, and 1 strong clasp knife with wooden handle, each person.	If these articles can be made sufficiently strong of wood, as recommended, it will be very desirable.
1 Small pepper box	Of pewter.

Tents and huts

94. *Tent* as used during expeditions from H.M.S. *Pioneer* (Osborn), 1852–54. Model 15 inches high with base $13 \times 12\frac{1}{2}$ inches. "Presented to John Barrow by the crew of Capt. Osborn's sledge."

This is very similar in design to the type which is now known as the "Whymper Tent." Whymper himself never claimed originality in the design: after experiments in 1862 he selected as most satisfactory the design "which had been arrived at, after great experience, by Sir Leopold M'Clintock." [1] The model has crow-foot guys on each side, and a heavy ice anchor attached to the front guy. Four boarding-pikes were used as tent poles. M'Clintock described the main features of this tent in a letter to the Secretary of the Arctic Committee in 1851.[2]

Similar model, unlabelled

Sherard Osborn[3] gives an interesting account of a night in one of these tents in 1853:

"The meal done, the tent was carefully swept out, the last sedulous arrangement of the pebbles, termed 'picking the feathers,' was made, and then a waterproof sheet

[1] Edward Whymper, 'The ascent of the Matterhorn,' pp. 61–63. London, 1880.

[2] *Report of the Committee* ... Enclosure No. 13.

[3] Sherard Osborn, *op. cit.*, p. 146.

spread to prevent our warm bodies, during the night, melting the frozen ground and wetting us through. Then every man seized his blanket bag, and popped thereinto his legs and body, in order that the operation of undressing might be decently performed, and placed jacket and wet boots carefully for a pillow. Lastly, the wolf-skin robes—oh, contractor of furs! may you be haunted by the aroma of the said robes for your lifetime!—brought along over and under the party, and all lie down alternately head and feet in a row, across the tent. Pipes are lighted,[1] the evening's glass of grog served out, and whilst the cook is washing up, and preparing his things ready for the morning meal, as well as securing the food on the sledges from foxes or a hungry bear, many a tough yarn is told or joke is made. The cook reports all right, hooks up the door, tucks in the fur robe, and seven jolly mortals, with a brown holland tent over their heads and a winter's gale without, try to nestle their sides amongst the softest stones, and soon drop into such a sleep as those only enjoy who drag a sledge all day."

97. *Tent.* Model 6 inches high on base 6×12 inches. Type used by Captain Penny during his exploration of Wellington Channel, 1850–51. The design evidently did not prove a success, for it does not appear to have been used again.

100. "*Northumberland House.*" Wooden model 4 inches high on base 8×6½ inches. Rectangular with a hipped roof, three small windows and double doors opening inwards, without a porch. Northumberland House on Beechy Island, named after the then First Lord of the Admiralty, was built by Commander Pullen when in command of H.M.S. *North Star*. The ship wintered there from 1852 to 1854 as a depot for Sir Edward Belcher's squadron. The house was built in the autumn of 1852, of lower masts and spars taken from the American whaler *M'Lellan*, which was crushed by the ice in Melville Bay in 1852.

124, 125. *Sleeping-bag* and *blanket.* Models of type used during Captain Penny's Expedition, 1850–51. The sleeping-bag is made of white cotton, 6×2½ inches, sewn all round except for a small opening at one corner.

Provisions[2]

The "scale of victualling" for H.M. Sledge *John Barrow* (No. 111) is given as follows: [3]

Name of article	*Daily quantity*	
	Per man	*For 8 men*
Pemmican	¾ lb.	6 lb.
Boiled pork	6 oz.	3 lb.
Biscuit	¾ lb.	6 lb.
Concentrated rum	3 oz.	24 oz.
Tobacco	—	3 3/7 oz.
Biscuit dust	½ oz.	½ lb.
Tea	¼ oz.	2 oz.
Sugar	¾ oz.	6 oz.
Chocolate (Moore's)	1½ oz.	12 oz.
Lime juice	¼ oz.	2 oz.
Pepper, salt, mustard, and onion powder	—	—
Cayenne pepper	2 oz. for 42 days for party.	

[1] Until about 1852 the pipes were lighted with a "slow match" which gave off fumes extremely painful to the eyes. Lieut. Sherard Osborn first introduced "wax bougies" for this purpose.

[2] For notes on the early history of the canning industry and recent analyses of some preserved foods taken on nineteenth-century British Arctic expeditions, see J. C. Drummond, *Chemistry and industry*, 57 (1938) 808–14, 827–36.

[3] *Further papers* . . ., p. 185.

During the year 1853 this sledge party made three journeys covering 1430 (statute ?) miles in 117 days. The total number of hours' travelling was 1021½, and of rest 2315. The ration was typical of the period, but there were variations then just as there are now. The proportions of pemmican and boiled pork were constantly being changed; sometimes preserved potato was taken instead of biscuit dust; the daily quantity of rum varied between ½ and 1 gill; tea alternated with Moore's chocolate. In fact the only item which seems to have remained constant was the tobacco ration of ½ oz.

One of the finest sledge journeys ever accomplished was that of H.M. Sledge *Discovery*, under command of Lieutenant Mecham, in 1854.[1] Calling at depots to revictual, his party travelled 1107 geog. miles (1279 statute miles) in 70 days. This distance was covered on a daily ration per man of ¾ lb. preserved meat, ½ lb. boiled pork, 2 oz. preserved potato, 1 lb. biscuit, ½ gill concentrated rum, ¾ oz. of tea and sugar (every other day), and 2 oz. Moore's chocolate.

Fuel and cooking apparatus

M'Dougall, who was master on board H.M.S. *Resolute* in 1852–54, gives an interesting summary of experiments made by Commander M'Clintock in 1853 to determine the relative merits of different types of fuel for cooking.[2]

		Time per pint					
Lamp	*Kettle pints*	*To dissolve*		*To boil from snow*		*Fuel*	*Temp. Air and snow*
Argand ..	13	2 min.	40 sec.	4 min.	48 sec.	Alcohol	−32° F.
5-wick ..	9	4	24	8	48	,,	,,
Stearine ..	13	3	54	10	0	Stearine	,,
,,	9	3	21	7	12	,,	,,
,,	9	6	0	16	0	Tallow	,,

There was some difference of opinion as to the most suitable form of fuel. M'Clintock preferred stearine on account of the danger of breaking the bottle of alcohol, but the men complained of the smoke of stearine being unbearable. To meet this difficulty Captain Richard Collinson made experiments with a mixture of oakum, oil, rosin, and saltpetre; but this does not seem to have been so satisfactory as Sir Edward Belcher's "cakes for sledge use," consisting of "two parts whale oil and one part stearine, eight inches in diameter, with several wicks." Alcohol was the most compact fuel known, but even with this it was often not possible to do more than warm the food. If the alcohol or "spirits of wine" ran low, the rum ration was sometimes used for cooking; while deficiency of fuel for the stoves burning stearine or tallow could be made up with pork fat or tallow from the preserved meat tins. Captain Austin[3] recommended that each of his parties of eight men should take one-half spirits of wine and one-half lard: 6½ gills of the former or 22 oz. of the latter per day. For the same number of men, Lieutenant Osborn found it best to use 6 gills of spirits of wine and 28 oz. of tallow.

[1] *Further papers . . .*, p. 690.
[2] George F. M'Dougall, 'The voyage of the *Resolute*,' p. 492. London, 1857.
[3] *Further correspondence . . .*, p. 107.

Mr. Bradford, surgeon of H.M.S. *Resolute*, wrote in 1851[1] that

"tallow was much preferred in my tent to the spirits, as it was more easily managed by the cooks in very cold weather, and required little preparation. The disadvantages attending its use were, that it could not be used inside the tent on account of the dense smoke it gave out; secondly it required some little time to solidify, when we were in a hurry to pack up, after our short halts at midnight for refreshment. The spirits of wine was not so much liked by the cooks, as the spirit lamp required constant attention to the wicks and was very cold to the fingers when handled. Six gills per diem barely suffices to give two warm meals, and a small quantity of water at midnight. This was more particularly the case when the temperature was minus in April and the early part of May. In June three and four gills was sufficient to cook our meals; but had it not been for the fortunate circumstance of shooting a bear giving a small supply of fat we should have been very hard up for fuel. The spirits of wine requires vessels for its safe custody and carriage, thereby increasing the weights; a great and important subject in all questions relating to sledge equipment. A lump of tallow is perfectly secure wrapped up in a piece of old canvass or placed in a bag which can be cut up to supply wicks to burn it with."

In the Barrow Collection there are two model stoves and one full-size cooking apparatus:

99. *Cooking apparatus* as used during Captain Penny's Expedition, 1850–51. Model made of copper, $1\frac{3}{4} \times 1\frac{3}{4} \times 2$ inches. This has a tray at the base for fuel which apparently burnt without a wick.

618. *Cooking apparatus* (undated). Circular model 2 inches in diameter and $2\frac{1}{4}$ inches deep; made of tin with large ventilation holes, copper bottom fittings, and shallow copper kettle. This has a single tubular wick, presumably for alcohol.

617. *Cooking apparatus* used by Captain Sherard Osborn. Circular, $7\frac{3}{4}$ inches in diameter and 6 inches high. When erected for use, this becomes 9 inches high. It contains a small kettle and an arrangement for conserving heat and melting extra snow—the forerunner of the Nansen Cooker. The burner has holders for five wicks and appears to have been used with alcohol. The whole apparatus is far more convenient than the cumbersome type used by Captain Penny.

Clothing

98. *Figure in Arctic dress with spade and pick-axe.* Model 12 inches high, showing canvas clothes and canvas boots with leather soles. Labelled "one of the men of the exploring party." (Undated.) In a letter to the Secretary of the Admiralty of 9 December 1851, Captain Austin advised the following clothing for each person during a sledge journey:[2]

Walking dress

1 Inside flannel.
1 Guernsey frock.
1 Serge frock.
1 Jumper.
1 Pair of drawers.
1 Pair of breeches.
1 Pair of over-all duck pantaloons, tied above the calf. (Considered necessary on account of snow drift.)

[1] *Report of the Committee* . . . Enclosure No. 14.
[2] *Further correspondence* . . ., p. 109.

1 Pair of stockings	(Double knitted at heel and toe.)
1 Pair of blanket feet wrappers ..	(Cut according to the North American Indian fashion.)
1 Pair of wadmill boot hose.	
1 Pair of canvass boots	(Made to fit easy over all. Thick canvass soles for early spring travelling. It is however considered that boots made of elk or some such skin would be preferable.)
1 Waist belt.	
1 Welsh wig.	
1 Light southwester.	
1 Comforter.	
2 Pairs of mitts with lanyards ..	(Inside pair of strong worsted, outside pair of leather.)
1 Leather water bottle	(Made flat to fit the body, no metal about it.)
1 Pair of spectacles.	

Spare clothing

1 Inside flannel pair of drawers.	
2 Pairs of stockings	(One for limited parties.)
2 Pairs of blanket feet wrappers ..	(One for limited parties.)
2 Pairs of boots, as in walking dress.	
2 Pairs of moccasins, as slippers ..	(One for limited parties; of light soft leather for wearing inside tent and sleeping, and that would serve also for a short march in the event of tender feet.)
1 Pair of light boots, strong soles ..	(For extended parties only. For the latter part of the season, when travelling is very wet. Should therefore be made, if possible, of some material that is water-tight.)
1 Pair of leather mitts.	

Boats

Boats were sometimes carried on sledges during the time when the ice was forming or breaking out. An ordinary's ship's cutter was carried by Commander Richards across Franklin Strait in 1853, but more often special boats, of lighter construction, were used. Major-General T. B. Collinson[1] records that four light ice-boats were built for Sir Edward Belcher's squadron. "They were 16–20 feet long, flat-bottomed, of extremely thin boards, covered with canvas, and weighing about 300 lb. each, and would carry eight persons."

There are two model boats in the Collection:

93. ***Sledge-boat on wheels.*** Scale model 23 inches long—as used by Sir Edward Parry during his attempt to reach the North Pole in 1827. The original was designed and built by Oliver Lang, Esq., Master Attendant at His Majesty's Dockyard, Woolwich. The plan to reach the Pole with this type of transport over the smooth fields of ice thought to exist north of Spitsbergen was originally proposed by Franklin, and was given to Parry by Mr. Barrow in 1826. The idea was largely inspired by Scoresby, who had written of this region: "I once saw a field that was so free from either fissure or hummock, that I imagine, had it been free from snow, a coach might have

[1] Richard Collinson, 'Journal of H.M.S. *Enterprise* on the Expedition in search of Sir John Franklin's ships by Behring Strait, 1850–55.' Appendix by T. B. Collinson.

been driven many leagues over it in a direct line, without obstruction or danger."

Two boats of this design were prepared. They were 20 feet long and 7 feet broad, flat-floored, strengthened and made elastic by sheets of felt between the planking, and covered with waterproof canvas. A runner, attached to each side of the keel, adapted them for easy draught on the ice after the manner of a sledge. They were also fitted with wheels to be used if deemed expedient, and could be adapted with a canvas awning for sleeping. Two officers and twelve men were attached to each boat, and they were named *Enterprise* and *Endeavour*. The weight of each boat, including provisions and full equipment, was about 3750 lb. Eight reindeer, with a large quantity of moss for their food, were embarked in Norway, but they were given up as useless owing to the rough nature of the ice, and because of the great incumbrance which they caused in the boats. The wheels were also discarded.

The northernmost point reached was 82° 45′. Parry wrote in his journal (July 27): "Our ensigns and pendants were displayed during the day and sincerely as we regretted not having been able to hoist the British flag in the highest Latitude to which we had aspired, we shall perhaps be excused in having felt some little pride in being the bearers of it to a parallel considerably beyond that mentioned in any other well-authenticated record." Failure to reach the Pole was due to the broken and rugged state of the ice over which they travelled, and to the drifting of the whole body of ice in a southerly direction. The journey lasted sixty-one days. "The distance travelled during this excursion was 569 geographical miles; but allowing for the times we had to return for our baggage, during the greater part of the journey over the ice, we estimated our actual travelling at 978 geographical, or 1127 statute miles." [1]

118. *Boat-sledge and section of boat.* Model of sledge 16½ inches long, with five cross-bars, on which is a longitudinal section of a wooden boat 23 inches long. As used by Captain Penny on his return from Point Surprise, in lat. 76° N., long. 96° W., where he found open water in May 1851.

Miscellaneous

86. *Monument to Joseph René Bellot.* Model 16½ inches high. Bellot was a lieutenant in the French Navy who served in the *Prince Albert* (Kennedy), 1851–52, and in the *Phoenix* (Inglefield), 1853. He was drowned at the age of twenty-seven on 18 August 1853, while with a sledge party from the *North Star* (Pullen), on his way from Beechey Island to convey dispatches to Sir Edward Belcher. The actual monument stands in front of Greenwich Hospital (see *Journal R.G.S.* 26 (1856) viii).

85. *Photograph of Bellot.* 2¼×3 inches. Presented by him to Mr. Barrow. It was taken at Aberdeen when he was about to embark on his first voyage in the *Prince Albert*, 1851.

133. *Ice-saw and triangles.* Scale model, 2 inches to 1 foot, legs of triangle 3 feet 1 inch long. This was designed by M'Clintock for an ice-saw 15 feet in length. Attached to the apex of the triangle is a pulley from which the saw is

[1] W. E. Parry, 'Narrative of an attempt to reach the North Pole in the year 1827.' London, 1828.

suspended by a chain. A cross-frame or handle of wood is attached to the upper end of the saw, and an iron weight or "pitman" to the bottom. The method of use is shown in the plate facing p. 373.

619. *Smaller model as above.* Triangle legs $14\frac{3}{4}$ inches long.

620. *Ice-chisel.* Model $13\frac{1}{2}$ inches long.

621. *Ice-pole.* Model 13 inches long.

622. *Ice-knife.* Model $7\frac{1}{4}$ inches long.

623. *Tamping rod.* Model $7\frac{1}{4}$ inches long.

These four items were used mainly in conjunction with ice-saws for cutting out the ships when they were beset.

134, 135. *Ice-hooks.* Two models presented by Mr. Rice. Made of steel; Y-shaped, with hooks at the forked end and a ring at the other.

136, 137. *Ice anchors.* Two models presented by Mr. Rice. Made of steel. These are similar to the type still in use.

138. *Flour.* Buried at Chamisso Island in 1827 by Captain Beechey of the *Blossom* for the use of Franklin when exploring the coast of North America. Dug up by Commander Moore, of the *Plover*, in 1849.

139. *Beads.* Eight strings about 10 inches long. Intended for presents to the Eskimo; buried and recovered as above.

140. *Small box of shot.* Found under the site of a tent which had been erected at Cape Riley, the winter quarters of Sir John Franklin in 1845–46. Brought home by Captain Penny.

Note on the illustrations

1. From "A series of fourteen sketches made during the voyage up Wellington Channel in search of Sir John Franklin . . ." By Walter W. May. London, 1855.

2. From the Supplement to the *Illustrated London News*, 11 November 1876.

3 and 4. From 'Arctic expeditions from British and Foreign shores.' By D. Murray Smith. London, 1877.

MAPS OF THE WORLD ON AN OBLIQUE MERCATOR PROJECTION

A. R. HINKS

DURING last summer I undertook to consider making some maps to decorate the British Section of the proposed Polar Exhibition at Bergen and began to work out a scheme for making world maps which would show in single sheets the relation of the rest of the world to the Polar regions. On the outbreak of war the Polar Exhibition was postponed, but a preliminary sketch seemed to show that the map which had been thought of first as a decoration might have serious value for the study of world-wide problems. A globe is awkward to use. One cannot very conveniently measure distances upon it or lay down lines upon it, and it is impossible to make tracings from it or to see both sides of it at the same time. Hence there would be an advantage in having a small series of maps designed to show different aspects of the world, of which one or other would serve for working out any problems that arose.

Though the problem of showing the whole surface conveniently on a single sheet is intractable, Mercator's projection gets nearer to it than one might think. The original projection carried to 70° north and south covers 94 per cent. of the earth, but at the limiting parallel of 70° the scale value has become three times that on the equator, the distortion is very great though formally the projection is orthomorphic, and beyond 70° it increases very rapidly, so that any representation gets unmanageable only a little farther from the equator than 70°. The usual table of meridional parts rather conceals the truth: perhaps because it is always constructed in minutes of arc. The following brief table shows the relation between the latitude, the equivalent meridional part expressed in degrees instead of in minutes, the area of the sphere included up to that latitude, and the scale value at that latitude.

Cylindrical Orthomorphic Projection: Normal Mercator

Lat.	*Merid. Pt.*	*Area betw.* $\pm\phi$	*Scale at lat.* ϕ
ϕ 45°	η 50·4990	70·71 %	1·4142
50	57·9079	76·60	1·5557
55	66·1328	81·92	1·7434
60	75·4561	86·60	2·0000
65	86·3135	90·63	2·3662
70	99·4320	93·97	2·9238
75	116·1723	96·59	3·8637
80	139·5866	98·48	5·7588
85	179·4104	99·62	11·4737

The distribution of land upon the surface of the sphere is more closely related to the Poles than to the Equator, and a useful world map should show the Poles even if it is not intended for a Polar Exhibition. Hence the need for something other than the normal Mercator or Cylindrical Orthomorphic Projections. It is well to preserve orthomorphism, if only for its help in solving great circle problems; and a transverse Mercator graticule drawn upon transparent paper and applied to the normal Mercator map can be used

conveniently for tracing great circles. Examples of it have been published by Monsieur L. Favé, Ingénieur-en-chef of the Service Hydrographique de la Marine. This same transverse Mercator projection is becoming much used in terrestrial mapping. It has for example been adopted for technical reasons in the recent Ordnance Survey maps. But the Transverse Mercator does not lend itself conspicuously to world maps, since world relations trend on the whole east and west rather than north and south.

Since one cannot be content with the conventional representations of the world in hemispheres or in sectors because the representation is not continuous, one is led to consider using the Oblique Mercator Projection for a set of world maps, each covering 94 per cent. of the whole surface, and with the poles of the projection chosen to give a variety of representations and relation to the poles of the earth. After some experiments such a projection was first calculated for pole 35½° north, 152° east, and a rough plot of the continental outlines showed it was better to renumber the meridians, adding 60° to the east longitude. The sketch now submitted is the result. It would have been better to add 50° instead of 60°, which would have reduced the great exaggeration of the north-west coast of America.

The calculation of oblique projections is rather long, which is perhaps why such projections have not to our knowledge been used before for the representation of the world. The work is much assisted by the use of Peters' table of natural functions with the arguments in decimals of a degree, and of the Swedish calculating machine, the Facit, which is a great improvement on the Brunsviga, since figures are set on the drum by pressing numbered keys instead of by pulling over levers.

The projection has been calculated for 10° intersections of the meridians and parallels, and since the sketch was made a number of intermediate 5° intersections have been calculated to assist in drawing the curves where they are widely spaced. Had the pole of the projection been chosen in a longitude which is a multiple of 10°, the graticule would have been more symmetrical; it would have sufficed to calculate it for a quarter of the sphere, and complete by reversals. I preferred to choose the pole at an intermediate degree, which doubled the calculations but much improved the elegance of the projection.

One has a second freedom of choice in placing the origin of coordinates upon the central great circle or principal axis of coordinates. It is not necessary that the poles of the earth shall be placed symmetrically between the limits plotted: and in practice one extends the projection over about 500° of the principal axis so that parts of the maps are repeated: and then, if one is limiting it to a complete circumference, one chooses the limits to make the convenient disposition of the world outlines within them. On the sketch reproduced (following p. 408) we have repeated only 10°, as a hint that repetition is desirable. In using the map it is convenient to dry-mount it on stiff card so that it will lie flat, and cut it into two equal parts, each covering 180° of the principal axis: these will fit either to right or left, and allow one to proceed continuously round the sphere on a belt up to 70° on each side of the central axis.

The first sketch, here published, has been extended a little beyond 70° from the principal axis towards the north, to include the whole northern coast

of America and Asia, even though it is badly distorted: this was done to make a severe test of the superimposed Transverse Mercator graticule for tracing great circles. There was no difficulty in constructing to within about half a degree the great circle from Panama to Yokohama across the Gulf of Mexico, the central United States, coming out somewhere about Prince Rupert and so round the northern shores of America and Asia. This may be found to justify extending the projection beyond 70° and tolerating the distortion: but only for private use, and not for general publication. Africa looks bad enough as it is upon our sketch, even though it has received the compliment of being compared with the silhouette of the Venus of Milo.

The next step will be to replot the outlines with different longitudes of the pole of projection: trial shows that an attractive example will be a map with the American continent lying about the principal axis. A set of about five maps will cover the world more than four times in various aspects.

The sketch now reproduced must be judged leniently as a sketch and not as a finished production. It is published in its present form with the intent that the author may receive criticisms and suggestions before considering further if a finished set of such maps shall be contemplated. Meanwhile it should be remembered that this kind of map was projected first as a scientific decoration, and that its use on a much larger scale as a frieze has attractive possibilities.

The use of rotary photogravure for map printing is still in the experimental stage. The map of Jan Mayen in two printings which we published in the *Journal* for August 1939 showed some of its possibilities. The map in the April number to illustrate Mr. John Wright's paper showed how much can be done in a single printing, but also that not all experiments are equally successful. Sometimes it is very convenient to be able to publish, as here, what was not in the first instance made as a drawing fit for reproduction: an experimental sketch on graph paper, to see what a projection will look like: as such it must be judged. We are greatly obliged to Messrs. Harrison and Sons, Ltd., for the continual help in advice, skill, and care which they are giving to our experiments. A much more ambitious map in four colours is now in preparation, from which we shall learn how the new process can be adapted to elaborate representation of relief.

ISOSTATIC MOVEMENT IN FINLAND

ON THE UPHEAVAL OF LAND IN FENNOSCANDIA. By ERKKI NISKANEN. Publications of the Isostatic Institute of the International Association of Geodesy, No. 6. (Reprinted from *Annales Academiae Scientiarum Fennicae*, Ser. A. Tom. LIII, No. 10.) *Helsinki*, 1939. 10×6½ *inches;* 30 *pages; maps*

IT is well known that the land around the Baltic is rising at a rate of a few millimetres a year. This fact has received an attempted explanation in terms of the recovery from the effects of the last glaciation. The extra load of ice, in accordance with the usual interpretation of isostasy, would have depressed the crust into the substratum. When it melted, on the same interpretation, there would be an inflow below and the land would rise. Niskanen attempts to develop this hypothesis quantitatively. He assumes that the behaviour of the substratum is represented by the equations of motion of a highly viscous fluid, though he calls attention to the "very disagreeable" feature that the upheaval has actually been discontinuous, the water-line having sometimes stayed at nearly the same level with respect to the land for long intervals of time. The crust has also apparently risen like a broken mosaic rather than by simple bending. However on the simple hypothesis used, Niskanen derives the formula, for the region of maximum uplift,

$$v = v_0(1+4kt)^{-3/2}$$

where v is the present rate of rise, v_0 the rate at time $t=0$, taken as about 5800 B.C., and k a constant related to the viscosity and the horizontal extent of the glaciation. From data for Ångermanland (on the Swedish side of the Gulf of Bothnia) he infers $k=1{\cdot}07\times10^{-4}$/year; the land has risen 250 metres and will rise about other 210 metres. For Finland detailed determinations of the rise are available, and from these Niskanen is able to get an estimate of the horizontal extent of the disturbance. On the whole fairly good agreement is found, but there are curious local complications. The viscosity is estimated as $1{\cdot}1\times10^{22}$ cm²/sec. The greatest stress-difference, having regard to the horizontal extent of the disturbance, would be at a depth of about 350 kilometres.

The relation to the present gravity anomalies is not close. The further rise to be expected in Ångermanland would suggest a gravity anomaly of −20 mgal there, decreasing towards the edges. This is about right for the shore of the Gulf of Bothnia, but there is a ridge of slightly positive anomalies running north-east from near Turku and Helsinki, and there is a patch of strong negative ones about Viipuri. But we might expect the present rate of rise to be strongly correlated with the gravity anomaly, which does provide a direct estimate of the present excess load. If the flow really exists to such a depth as Niskanen infers, this local variation would be superposed on a general rise; but Viipuri is about 500 kilometres from Ångermanland, and in present conditions we should expect the rate of rise to be greatest at Viipuri and on the coast, with a minimum or reversal about the Helsinki ridge. Actually it seems to increase steadily from Viipuri to the Baltic. This is a very serious objection to any theory of viscous flow. For a viscous substance has no memory; its flow depends entirely on the present stresses, which are known from the gravity anomalies. Niskanen suggests that the latter may be due to the inequalities of density near the surface; but this is irrelevant. Whatever they are due to they correspond to the same inequalities of mass per unit area, and the same stresses are required to maintain them. On a viscous theory Viipuri should be rising faster than Helsinki, and the

contrary is the case. Accordingly, though Niskanen has done a service to geophysics in carefully working out the consequences of the viscous theory and collecting the relevant observations for comparison, what he has shown is that it does not represent the present facts, and that some at least of the present uplift is taking place in spite of differences of load and not because of them.

Attention may be called here to other instances of difficulties in any theory that treats the substratum as passively yielding to any variation of surface load. Sicily, one of the well-known regions of alternate rises and sinkings in historic times, is a region of considerable positive gravity anomalies, and all changes should have been depressions. The recent work of Mace in Cyprus has shown very large positive anomalies; there seems to have been no change of level in historic times, but there has been a rise since the Pleistocene.[1] The island has risen in spite of being too heavy. Rises apparently analogous to the Scandinavian one have been studied in Canada and also attributed to viscous recovery since the glacial period. If this was correct they should be largest near Hudson Bay. But W. A. Johnston finds no uplift there.[2] The only inference that seems possible on this evidence is that the earth down to some considerable depth is undergoing spontaneous change, to which the outer surface has to adjust itself as well as it can and which surface load can do nothing to prevent. But the surface load is acting all the time, and if there was a finite viscosity the load would stop or reverse the currents immediately. Since it does not, the lower layers must have a finite strength; in other words the viscosity is infinite.

HAROLD JEFFREYS.

[1] C. Mace and E. C. Bullard, *Mon. Not. R. Astr. Soc. Geophys. Suppl.*, 4 (1939) 473–80.
[2] *Amer. J. Sci.* (1939) 94.

REVIEWS

EUROPE

THE MEDIEVAL FENLAND. By H. C. DARBY. xviii+200 *pages.* 12*s* 6*d.* The draining of the Fens. By H. C. DARBY. xx+312 *pages.* 21*s.* (Cambridge studies in economic history.) *Cambridge: University Press,* 1940. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches; illustrations and sketch-maps*

Dr. Darby's long-awaited study of the Fenland depicts the changing geography of this distinctive region and the economic life which it sustained. These two excellently produced volumes, which survey the Fenland from early times until the threshold of the present, divide an indivisible story, and if the work had grown too large for a single volume, much space could have been saved by more précis and less copious quotation. Dr. Darby has however produced a work of considerable interest and novelty, for regional history of this kind and quality is unfortunately rare in this country.

Dr. Darby has shaped his narrative from a mass of contemporary material and from the products of modern research, and has enriched it with numerous maps and photographs. In the first volume he dispels the exaggerated legends about the "half-savage" Fenmen, and reveals in its true proportions the nature of their medieval economy. Intercommoning practices, communications, litigation, and the activities of the Commissioners of Sewers are all discussed, and medieval statistics are reduced to map form, often with striking results. The larger second volume reviews in detail the many attempts at, and final success of, scientific draining, and describes the various works of reclamation and resultant agricultural changes. An important chapter is devoted to the problem of the outfalls—so long the Achilles' heel of Fenland drainage schemes. The author is concerned with the internal aspect of the region; its external aspect, for example, the medieval trade of the Wash ports, falls outside the limits of his task.

The novelty of this contribution to regional history stimulates criticism, however ungrateful this may seem. The author handles the literary documentation of his history with proper caution but with excessive respect. At times he seems to try to efface himself, to let long quotations replace his narrative, and to leave these, together with his maps, to "speak for themselves." Often indeed the maps call for expert interpretation, and have little to say to the economic historian if left unguided. Often, too, distributions might have been related to the physical background. It is odd that although a full physical survey of river and flood regime seems called for and would be particularly helpful to students of history, Dr. Darby is content with two sound but slight introductory pages on the physical geography in volume I and a number of asides here and there. The causes which explain the worst floods are consigned to a footnote on p. 57 of volume I. Dr. Darby is so excessively cautious that he tells us little about Roman Fenland and nothing at all of its prehistory, because the story has not yet been fully unravelled. Nor will he focus the evidence of storms, floods, and droughts which he has at hand, imperfect though it is bound to be, on the debated question of fourteenth-century climate.

If some opportunities to correlate history and geography appear to have been missed, nevertheless historians and geographers have every reason to be grateful to the author for his industry and zeal. The Fenland of to-day is, as Michelet said of Flanders, "the work of Man in despite of Nature." Dr. Darby recounts with authority the nature of, and the stages in, man's making of the Fenland. He

gives man and his work the close attention which they deserve, but is curiously reticent about those physical forces and conditions which challenged the Fenmen to wage their age-long struggle. W. G. E.

LONDON FABRIC. By JAMES POPE-HENNESSY. *London: B. T. Batsford, Ltd.*, 1939. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches;* viii + 184 *pages; illustrations.* 10*s* 6*d*

This is an account of recent visits paid to museums, galleries, and palaces in and near London by a young man and a vivacious lady. Upon his companion the author lavishes his varied stock of historical learning, making of the monuments, pictures, and *objets d'art* that he shows her pegs on which to hang it. He has a pronounced preference for Tudor and Carolean flamboyance and little use for the more modest taste that succeeded it. The book does not pretend to add to our knowledge and is a trifle too didactic and self-consciously clever. The treatment however of a rather hackneyed theme possesses a degree of originality. The illustrations are neither so numerous nor so interesting as the publishers generally provide. R. B. P.

SARN HELEN, a Roman road in Wales. By MORRIS MARPLES. *Newtown, Mont.: The Welsh Outlook Press*, 1939. $10 \times 6\frac{1}{2}$ *inches;* 45 *pages; illustration and maps.* 2*s* 6*d*

This pamphlet traces the course of the Sarn Helen, the late first-century Roman road that runs from Caerhun in Caernarvonshire to Llanio in Cardiganshire. Hence one branch continues to Carmarthen, while another turning eastwards passes Y Gaer, near Brecon, and thence south-west to Neath. The author has followed the whole course of this important ancient highway, for the most part on foot, and his detailed discussion of each section of its course, illustrated by a series of sketch-maps based on the Ordnance Survey, is the result of good field work. Earlier authorities have been consulted as an aid to personal observation in the many places where the exact course of the road is unknown. The account of such sections is clearly written and properly cautious in tone, for finality could only be reached by a laborious series of excavations. Such regional studies as this are to be warmly welcomed, and the author is fully justified in his hope that his pamphlet will prove "useful not only to those who take an academic interest in the course of Roman roads, but to others—there must surely be many of these to-day—who may feel inclined to follow Sarn Helen for themselves and combine walking (and perhaps camping) with archaeology." P. C.

COUNTRY NOTES. By V. SACKVILLE-WEST. Illustrated with photographs by BRYAN and NORMAN WESTWOOD. *London: Michael Joseph*, 1939. $10 \times 7\frac{1}{2}$ *inches;* 220 *pages.* 10*s* 6*d*

Miss Sackville's skilful delineation of the pleasures of garden and countryside is effectively heightened by contrast with the urgency of public affairs. Her notes form a calendar of the gardening year which will be enjoyed both by those able to profit from her experience as well as by those who merely share her preference for a rural life, however unlikely it may be that they will follow her into seclusion. Others too will appreciate the author's self portrait, largely conveyed by implication, and the attractiveness of the prose style. As she is aware, it is difficult to write of the countryside without preciosity or an often irritating self-consciousness, but a sense of humour and an ability to see both sides of a question have saved her from this fault. Beneath the unassuming exterior her book conveys an amount of out-of-the-way information, much of it due to her keen powers of observation. The accompanying photographs, if occasionally rather sombre, interpret the spirit of the text. G. R. C.

THE ISLAND OF ZEUS: wanderings in Crete. By RALPH BREWSTER. *London: Duckworth*, 1939. 9×5½ *inches;* 360 *pages; illustrations.* 15*s*

From the photographic point of view the illustrations which grace this book on Crete, the Greek island where Zeus was born, would be difficult to surpass. Their composition is strong, their lighting effective, and their subjects, with one unfortunate exception, well chosen. It is however surprising that an author sensitive enough to express resentment at the superimposition of what he calls modern ruins on the ancient ruins at Knossos, should not have felt the intrusiveness of the ultra-modern Freddy, his Austrian travelling companion, in photographs of the ancient landscape of Crete. Both illustrations and text give a lop-sided impression of Crete because the author travelled in autumn, the rainy season. The island is far sunnier than his beautiful, beclouded landscapes imply; and he never saw, and has therefore said nothing of, Crete's greatest present glory: its rich flora.

The text falls into two skilfully intermingled sections. The first, covering the author's day-to-day movements with Freddy and the donkeys, conveys adequately the beauty of outline of the Cretan mountains and the charm of the olives, vines, oranges, and carobs that stud the plains. The description of the site of ancient Phaistos is one of the best. In his accounts of Cretan antiquities the author has the good sense to quote his learned predecessors; when he deviates from this rule to criticize the achievements of Sir Arthur Evans, the results are unhappy. The section as a whole is spoiled by incessant confidences about his financial difficulties and his ignoble quarrels with policemen. The second section of the text retails local stories, some modern, others ancient. Here the author succeeds very fairly in reproducing local colour, particularly in his description of Spinalonga, the leper island.

The book is avowedly the work of a man who travelled to write, and of this class it is a good specimen. M. M. H.

ASIA

HIMALAYAN QUEST: the German expeditions to Siniolchum and Nanga Parbat. Edited by PAUL BAUER. Translated from the German by E. G. HALL. *London: Nicholson and Watson*, 1938. 10×7½ *inches;* xxvi+150 *pages; illustrations and maps.* 21*s*

This book records the successful attacks of the German parties on Siniolchum and one of the Sinvu peaks in Sikkim, and the disaster which overwhelmed Dr. Wien's party on Nanga Parbat in 1937. The translation is adequate, but too close adherence to the original text is a handicap in translating German narrative if, as may easily happen, the result reads somewhat sentimentally in a foreign tongue; and in this book the translator might well have taken some latitude in detail. The photographs are all notable, often magnificent, though the reproduction is not up to the high standard set in 'Deutsche am Nanga Parbat.' The story is well set out, with every relevant fact, and it is easy to follow the climbers on their way. We feel however that the author's decision to embody large portions of the climbers' diaries breaks the continuity of the tale and leaves the impression of too many hands in the composition of this book. Dr. Bauer gives every credit to his companions and pays the fullest tribute to those who lost their lives on Nanga Parbat, the *Schicksalsberg* of German mountaineers. One reads with admiration of the fortitude alike of those who met their death and of those who came so rapidly to the scene of disaster. It is to be hoped that the tradition established by these brave men may live once more and that the success of others may bring fresh honour to the pioneers who find a fitting memorial in this volume. H. E. G. T.

PURCHAS HIS PILGRIMES IN JAPAN, extracted from Hakluytus Posthumus or Purchas His Pilgrimes and edited with commentary and notes by CYRIL WILD. *Kobe: J. L. Thompson*, 1939 (*London: Kegan Paul*). 9×6 *inches;* viii+284 *pages; facsimile maps, etc.* 10*s* 6*d*

Mr. Wild's object in compiling this volume has been to extract and rearrange all Purchas' material relating to Japan. His order is mainly chronological and falls under four headings: the early explorers (including Marco Polo's hearsay account of the country) down to the mid-sixteenth century; the Jesuits, who were the dominating foreign influence in Japan during the second half of the same century; the Dutch who, arriving in the country in 1600, were the only Europeans to establish themselves permanently; and, finally, the English who maintained a somewhat precarious trading connection there from 1613 to 1623. This rearrangement alone would not have justified the publication of a new edition of the Pilgrims, but Mr. Wild has embellished the text with some useful footnotes on Japanese nomenclature, implementing these where necessary with historical notes and appendices. He has also included a brief survey of contemporary exploration: while this may satisfy the general reader for whom the editor is partly catering, it will only irritate the student (whom he also has in mind) by its over-simplification of the motives and objectives which lay aback of Renaissance enterprise. Thus we are assured that "the great navigations of the Middle Ages were inspired by the wish to discover a safe sea-route to the luxuries of the East" and that Columbus was merely concerned to find "the eastern verge of Asia." The book is well produced and adequately indexed; the illustrations are clear, if unoriginal. G. H. T. K.

AFRICA

THE GEOLOGY OF SOUTH AFRICA. By ALEX. L. DU TOIT. Second edition, revised and enlarged. *London: Oliver and Boyd*, 1939. 9×5½ *inches;* x+540 *pages; illustrations, folding map, and sections.* 28*s*

The first edition was reviewed in this *Journal* for July 1927. The bulk of the volume has increased, partly through the use of larger type, which improves the appearance of the letterpress. There are however many small additions and alterations, some new illustrations, and several of the maps have been re-drawn in a more vigorous style.

The largest amount of additional matter is incorporated in the chapter on the Witwatersrand system, and in that on economic geology, as might be expected in a work on the principal gold-mining region of the world. The greatest amount of revision is in chapters VII and VIII, the result of the discovery of fossils in the Nama system and the consequent removal of that system to a higher level; this has necessitated changes in colouring on the geological map.

The author is well known to be a supporter of the theory of continental drift, but he says no more on the subject than any impartial writer might do, and points out alternative possibilities. This new edition not only maintains but improves upon the high standard of the first. A. M. D.

MADEIRA, CANARY ISLANDS, AZORES, WESTERN MOROCCO: handbook for travellers. By KARL BAEDEKER. *Leipzig: Karl Baedeker—London: George Allen and Unwin*, 1939. 6½×4 *inches;* xx+128 *pages; maps and plans.* 5*s*

Besides a section on each of the groups of islands, the volume contains a useful introduction, a section on the voyage down Western Europe, and another on the journey to Barcelona and Genoa with considerable descriptions of ports of call,

such as Oporto and Lisbon, and places in Western Morocco. It is therefore much more than a guide to the islands, though their section may have suffered slightly by reduced space. The maps, which include town plans, are uneven in character. There are double-page maps of the English Channel and the Tagus Estuary, and a large folding plan of Lisbon, while there is only a scrubby map of the Azores, with two insets on a single page and no town plans (this has three entries in the list). All are useful, but the Azores deserve better cartography. Heights in the text are given in feet, but they are in metres on the maps without obvious note. Sta. Anna, given correctly on the map of Madeira, is referred to in the text (p. 42) as Sta. Ana.

The various sections follow the familiar construction of Baedeker's guides; they are packed with interesting and useful information, which is mostly well up to date. The diabase of Madeira, which is certainly intrusive, is however still mentioned as being the oldest formation. The Madeira yam, *Colocasia*, is said to be *Dioscorea*, which also occurs. That dreadful pest, the Argentine ant, came in about 1890 and not 1850. The dryness of the climate of the central Canaries, with its conspicuous effect on the vegetation, might have been contrasted with the humidity of Madeira. There is an obvious error in the temperatures of Ponta Delgada (p. 111), where the figure 83° should be the average summer maximum. Banger's Pillar in Funchal was built to assist in unloading ships, but only its later use as a signalling station is mentioned. These however are small matters in a handy and convenient guide issued at a popular price. The essentials are all present, including an adequate description of the ascent of the Peak of Teneriffe, now facilitated by a motor route to the Cañadas. This little book can hardly fail to increase the pleasure and interest of the visitor to these islands. G. W. G.

CENTRAL AND SOUTH AMERICA

ECUADOR THE UNKNOWN: two and a half years' travels in the Republic of Ecuador and Galapagos Islands. By VICTOR WOLFGANG VON HAGEN. *London: Jarrolds*, 1939. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches; 296 pages; illustrations.* 16*s*

The object of Mr. von Hagen's two and a half years' travels in Ecuador and the Galapagos Islands was to make botanical and zoological collections, and to study the head-hunters of the upper Amazon and the Colorado Indians of the coastal forests. His adventures in the Amazon basin have already been told elsewhere, and are only briefly referred to here; but with this exception his book presents a representative cross-section of Ecuadorian topography.

Mr. von Hagen is an American field naturalist. As an American he appreciates better than most European travellers the economic and political context of the country, and as a naturalist he fills in the background of his narrative with accounts of scenery, plants, animals, and native customs. Compared with most books of its kind the narrative is excellent, especially in accounts of actual scenes such as the fair at Otovalo. The reviewer can vouch for the accuracy of the details in this particular chapter and believes that the facts stated in the remainder of the book are equally reliable.

The author is not so successful with the wider aspects of his subject. Two chapters, excellent in intention, on Panama hats and the cultivation of cocoa, are too anecdotal, and the impression left by the book as a whole is confused and evanescent, in spite of the excellence of its parts, and the attractive style in which it is written. The photographs are good, but not outstanding. The absence of any up-to-date map is a serious defect. G. I. C.

REFUGE IN THE ANDES. By RUDOLPH MESSEL. *London: John Lane*, 1939. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches; 286 pages; illustrations.* 10*s* 6*d*

The bickering and difficulties of a small group of evacuated Germans who had been installed on some land in the Colombian Andes at Cajibio, near Popayan, are used as a peg upon which to hang a great deal of tiresome political discourse. The author seems to be out of sympathy with the country and was quite unable to face the prospect of four days' holiday on a farm in the Cordillera without a book to read. There is a deal of drinking whisky and aguardiente, whilst altitude is blamed for symptoms which might have other causes. There is one strange reference to measures. In nearly all South America petrol is packed in 4-gallon tins, and yet when this amount was required it is said to have been obtained in two 2-gallon tins which are rarely if ever seen in South America nowadays. The book is illustrated by a few photographs, of which a view of the mountains between Ipiales and Quito is outstanding. J. V. H.

JOURNEY TO THE WORLD'S END. By HAKON MIELCHE. *Edinburgh, London: William Hodge and Co., Ltd.* (1939). 9×6 *inches;* viii+298 *pages; illustrations and map.* 12*s* 6*d*

This is the account of a journey from Copenhagen to Tierra del Fuego and of excursions made within reach of Sandy Point (Magellanes in Chilian parlance), with the rounding of Cape Horn as a fitting climax. Reasons given for the journey in the opening chapter strike the reader curiously. "I thought of the notorious Cape at the end of the world—I wished to learn more, but none could tell me." Further, "Tierra del Fuego has had but few prophets in Europe—these are Nordenskiold, Aaostini, Skottsberg and Pluschow." One recalls in bewilderment the names Darwin, H.M.S. *Beagle*, the French Mission du Cap Horn in 1904, the records of the South American Missionary Society, and periodical reports of the Chilian and Argentine Governments during the past half-century, with many others, all apparently ignored. Bewilderment grows on reading later of a Hamburg South American liner wrecked in the Beagle Channel on her second annual trip to these "unknown" regions with 1500 Argentine tourists, all of whom were safely landed at the nearby Argentine settlement of Ushuaia. The explanation of these apparent contradictions is that we are reading an expanded diary, whose successive chapters reflect a pilgrim's progress southward.

Mr. Mielche's journalistic flair early led him to realize that most of his acquaintances in Tierra del Fuego had unusual stories to tell. These he relates well and they convey the pioneer atmosphere of such ocean frontiers. Notes on the three Fuegan tribes are less happy, if only because they are necessarily second, if not third-hand. He seems unaware that the remnant of the Ona tribe are now settled at Viamonte, the sheep-farm of the Bridges family, their friends of forty years' standing. But he appreciates fully the fascination of this austere archipelago, scene of so much heroism and hairbreadth adventure, albeit often undertaken for sordid ends. The thumb-nail drawings that appear on the margin of every page illustrate sufficiently the author's sense of humour, which has helped him to endure discomforts that to a less experienced and adaptable traveller might have been hardships. Local photographs of landscape and fauna are well selected. The best is a close-up of Cape Horn, taken in profile from the south-west, showing its striking resemblance to Gibraltar. Such pictures of the stormy Cape are much rarer than have been the expeditions made to view it. W. S. B.

AUSTRALASIA AND PACIFIC

LAND UTILIZATION IN AUSTRALIA. By S. M. WADHAM and G. L. WOOD. (Issued under the auspices of the Institute of Pacific Relations.) *Melbourne: University Press—London: Oxford University Press*, 1939. 10×7 *inches;* xx+360 *pages; illustrations and maps.* 21*s*

Few people fully realize the difficulties facing the investigators of land utilization in Australia. The enormous continental surface is topographically unmapped, and politically subdivided, so that any Commonwealth-wide investigation is liable to be wrecked for the want of precise information due mainly to the failure of the governments to set aside an adequate supply of trained research workers. The authors of the present work abandoned a detailed survey as impracticable and wisely chose to treat each primary industry from the historical, physical, and regional aspects. During their inquiries, which began in 1932, they have had access to all sources of reliable information, official and unofficial. In the past the resources of the land have been estimated by several Government departments in the respective States, each department even within the one State working more or less independently of the others. The Lands Department maps occupations and classifies land for subdivision and reappraisement; the Railway Department and the Water Supply and Irrigation Commission have independent surveys for their own needs; in most States the Statisticians Department collects independently through police patrol officers statistics of production. Land utilization can thus only be presented in a generalized manner, but the present work correlates the separate efforts of all these departments, and incorporates data made available by such powerful unofficial bodies as the Pastoralists Association.

As the investigation proceeded it became clear that the generally accepted theory, that the sequence of land use in a young country reveals a growing intensification from extensive utilization to intensive and diversified utilization in response to increasing population and capital, did not apply in Australia. In sifting the data the authors found that land utilization in Australia was affected primarily by climate, with special emphasis on rainfall, soil fertility, population pressure, availability of capital at that time or stage of growth, the equipment of the operatives, and the character of the overseas markets. Secondary factors were the system of land tenure as an aid or hindrance to differentiation in use, the accessibility of the hinterland from the seaboard, the political attitude towards the rural districts, and the stage of development reached by secondary industries. The authors faithfully investigate the interrelation of soil, temperature, moisture, topography, and geological formations so as to determine what an area can produce. They also demonstrate how sensitive the rural industries of Australia are to fluctuations in the overseas markets.

The book will remain a standard reference and should encourage other geographers to examine land utilization in detail and on a regional basis. Its effectiveness would have been improved by the addition of summaries and a list of references at the end of each chapter. The footnotes, though serviceable, are not thoroughly adequate.

The high standard of the cartographical work in a few instances has been lost in the reproduction. Several of the maps and diagrams should have been reproduced as folded sheets or retained as double-page features; as, for example, the excellent vegetation coloured map, Fig. 19. Despite this slight drawback they form a valuable adjunct to the text. As a reference volume, the value is enhanced by a very efficient index which might have been enlarged, for the use of English readers, to include place-names.

Though the authors have triumphed over great difficulties, their work is not the complete story of land utilization in Australia. Rural settlement is so new, so experimental, and recent technical advances in the knowledge of the problem of agriculture have been so considerable, that there is no means of ascertaining their long-range effects. The authors define the present position; they also venture to suggest the trend of future developments and to indicate the economic and geographic factors which will be likely to accelerate or retard them. The historical approach, showing how invention and scientific work in the past have affected land utilization, provides a clue to future developments.

K. C. C. T.

EXPERIMENTS IN CIVILIZATION; the effects of European culture on a native community of the Solomon Islands. By H. IAN HOGBIN. *London: George Routledge*, 1939. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches;* xviii+268 *pages; illustrations and sketch-maps.* 15*s*

In this book the author describes the indigenous culture of Malaita in the Solomon Islands; the effects produced upon it by administrative measures, missionary activity and European economic enterprise; and possible alterations in policy which might eliminate present maladjustments.

In the admirably condensed survey of indigenous culture the chapter on "Economics and leadership" in particular will repay careful study. Dr. Hogbin's treatment of the relation between generosity and prestige is a model of ethnological analysis. The author presents the results of his field work not in any haphazard way, but with reference to clearly envisaged problems; there is ample documentation, but no irrelevant material is introduced; each ethnographic observation falls into place as part of a working institutional structure; and the lively episodes from native life, in the description of which Dr. Hogbin is an acknowledged master, are all presented as part of a dynamic process of cultural adaptation.

Law, religion, and magic are similarly treated. The brief discussion of marriage and sexual life is of some ethnographic interest from the comparative point of view. The people of Malaita depart surprisingly from what we usually regard as the primitive conception of sex. Their attitude would raise no objection from the sternest puritan.

The discussion of culture contact includes a valuable critical section on depopulation. Dr. Hogbin discounts the psychological factor and argues convincingly that introduced diseases and lack of hygiene adequately explain the fall in population which, in the Solomons as elsewhere in the Pacific, followed European conquest. The breakdown of native culture and the decay of traditional standards is however a serious social problem, particularly as it affects the control exercised by the older generation; the effects of the labour market in concentrating wealth in the hands of the young and some of the results of missionary teaching are discussed in relation to this. The author gives a revealing picture of the way in which Christianity has been reinterpreted by the natives in terms of indigenous religion, even to the extent of employing prayers as a substitute for the sorcerer's spells. The reader wonders whether it is the mission community or the Gospel which can more properly be described as "converted."

The final section contains a number of constructive suggestions bearing on future administrative policy, native labour, missions, and education. Each of these is discussed in the light of comparative material from Africa and from other parts of the Pacific. It is to be hoped that they will receive consideration by the administration and by others responsible for native welfare.

This book can be recommended alike to the general reader, to the student and

specialist, and to all who are interested in the future of native races. It is a valuable contribution both to scientific anthropology and to constructive colonial planning. R. P.

POLAR REGIONS

GEOLOGICAL INVESTIGATIONS IN EAST GREENLAND. Part III. The petrology of the Skaergaard intrusion, Kangerdlugssuaq, East Greenland. By L. R. WAGER and W. A. DEER. (*Meddelelser om Grønland*, Bd. 105, Nr. 4.) *Copenhagen: C. A. Reitzel*, 1939. 7×10½ *inches; 352 pages; maps, plates, and diagrams. Kr.20.00*

The Skaergaard gabbro complex, on the east side of Kangerdlugssuaq fjord near its mouth in lat. 68° 10′ N., long. 31° 40′ W., was discovered by Mr. Wager during the British Arctic Air-route Expedition in 1930. A preliminary map was made by him in the course of the Scoresby Sound Committee's second East Greenland Expedition in 1932, but the detailed study of the intrusion, the results of which are now presented, was carried out as one of the principal objects of the British East Greenland Expedition 1935–36, a general account of which, by Mr. Wager, has already appeared in the *Journal* for November 1937, pp. 393–425.

This book is an outstanding contribution to petrogenetics, in particular to the problem of the association of gabbroid and granophyric rocks. The association is so widespread that a mechanism by which both types could be derived from a common source has naturally been sought. Many authorities believe that such a mechanism is to be found in the fractional crystallization of basaltic magma. The Skaergaard intrusion has provided a fortunate opportunity for testing the efficacy of this process.

The intrusive body has the shape of an inverted cone, injected into acid gneisses of the metamorphic complex, sediments of supposed Cretaceous age, and Tertiary lavas. The magma was cut off at an early stage from the reservoir whence it came, but its original basaltic composition is accurately known from the chilled rocks on the margins of the intrusion. Slow crystallization of the magma, totally enclosed in what may be regarded as a huge crucible, has given rise to a variety of rocks, the study of which has enabled the authors to trace the course of differentiation of the magma. Their results convincingly demonstrate that fractional crystallization, aided by convection currents, brought about differentiation into a continuous series ranging from magnesia-rich gabbros to iron-rich gabbros ("ferrogabbros"). It did not of itself give rise to a granophyric residuum. Granophyre nevertheless appears in the Skaergaard complex, but the authors show, on good evidence, that it was produced by the incorporation of acid material from the metamorphic complex in the magma. They further conclude that the calc-alkaline suite of igneous rocks is in the main the result of mixing of basic and acid material.

Apart from a marginal zone round the sides of the crucible consisting of rapidly cooled material, the mass of the intrusion is composed of gabbros in which the alternation of bands of predominant light and dark coloured minerals is a striking feature. It is a feature common to gabbros in all parts of the world, and its origin is a problem of general interest. The authors have advanced the most satisfactory explanation yet offered, namely that it is due to sorting of minerals by convection currents of varying velocity.

The petrographic and chemical work, which is based upon the precise determination of each mineral, leaves nothing to be desired. The results are presented in such a way that the book should make interesting reading even for the

petrological layman. To those who are technically interested the work has a satisfying completeness very rarely found in the literature of the subject. It is admirably illustrated with a map, diagrams, photographs, and photomicrographs. K. C. D.

WISSENSCHAFTLICHE ERGEBNISSE DER DEUTSCHEN GRÖNland-Expedition Alfred Wegener 1929 und 1930/31. Edited by KURT WEGENER and others. Band IV. Meteorologie. 1. Das Beobachtungsmaterial. 2. Die Ergebnisse. By J. GEORGI, RUPERT HOLZAPFEL, WALTER KOPP, and KURT WEGENER. *Leipzig: F. A. Brockhaus*, 1935, 1939. 11×6½ *inches;* viii+560; viii+380 *pages; sketch-maps and diagrams. M.*47.40; 25

A general account of Wegener's last Greenland expedition, which cost him his life, appeared in the *Journal* for December 1934. The whole scheme was conceived and carried out on a grand scale. Three main stations were established and well equipped about lat. 71°, one on each coast and one in the middle of the ice-cap 10,000 feet above sea-level, besides subsidiary stations, and a full programme of observations was maintained for a full year. A great attraction of expeditions to Greenland is that they combine adventure and exploration with pioneer scientific work. A number of expeditions have brought back valuable material, but as far as meteorology is concerned, this one surpassed them all and provided a storehouse which cannot be exhausted for a long time to come. The volumes of scientific results are a fitting memorial to Wegener.

The object of the expedition was glaciological at least as much as meteorological, but the volumes under review are devoted mainly to meteorology. The first volume, giving the observations, was published in 1935, and the second, which discusses them, both statistically and to some extent individually also, appeared in 1939. W. Kopp deals with the East Station in both volumes, and R. Holzapfel with the West Station, while the ice-cap data are set out by W. Georgi in the first volume and discussed by Professor Kurt Wegener in the second. The observational material includes all the usual features. All the autographic traces of the various elements, including solar radiation, are reproduced for the ice-cap station, and the barograms at the other main stations also. There are also many measurements of upper winds and some soundings of upper air temperature and pressure, published in full.

In a short review it is only possible to indicate a few of the more important general conclusions, especially those arising from the ice-cap observations, the crowning achievement of the expedition. This station was on the west side of the highest point of the ice-cap at that latitude, so that the katabatic or downward gravitational flow of cold air reinforced the prevailing east to south-east winds. The upper wind soundings showed that although there was much irregular variation, east to south-east winds predominated up to 2 kilometres above the station, above which level there was no dominant wind.

The various authors recognize the great complexity of their subject and avoid facile generalizations. The phrase "glacial anticyclone" occasionally appears, but with qualifications. It would be better to drop this expression entirely. The outflow of gravitational winds from an ice-cap is so different from the outflow from an anticyclone, both in its causes and in its relation with the surrounding atmosphere, that the term is misleading. Barometric pressures in the middle of Greenland reduced to sea-level have no conceivable meaning. The material for direct comparison between pressure on the ice-cap and at 3 kilometres (10,000 feet) over the coast stations is small, but it provides no evidence of high pressure over the ice-cap. Owing to the disturbed nature of the region, and the draining effect of the katabatic winds, there is no chance of much accumulation of cold

air over the ice-cap. The upper air temperature soundings mostly show shallow cold air with an "inversion" (*i.e.* increase with height) near the ground both in winter and summer.

The soundings at the coast stations also show a high proportion of inversions. The cold air from the interior spreads into a shallow layer, and this limits its importance as a source of cold air affecting distant regions. There is no evidence that Greenland is more important in this respect than an equally large snow-covered land area at sea-level, or perhaps even a region of frozen sea, though the latter is affected by heat coming up through the ice. The chief meteorological importance of the Greenland mountains is the barrier they impose on air motion. On some occasions this indirectly affects even a region as far off as the British Isles.

The disturbed nature of Greenland weather, apart from local winds, is due to the position relative to the tracks of depressions, which in turn are affected by the vast area of warm water to the south, extending to the Gulf of Mexico, contrasting with the arctic regions, including in winter the intensely cold region of North Canada. There is an inset diagram in the cover of the first volume which unfolds to a length of over 4 feet and shows the fluctuations of pressure, temperature, wind, and cloud on the ice-cap. Apart from a few short anticyclonic spells, mostly in summer, there was a continuous series of cyclonic depressions, passing mostly to southward but occasionally moving up the west coast or right across Greenland. Those which cross Greenland form an important class as they commonly intensify when they reach the warm ocean to eastward. They have usually moved eastward over North Canada and often originate in the Pacific. Anticyclones crossing the Greenland area generally move south-east from the far north, and often cause cold snaps in the British Isles, especially those crossing north-east Greenland.

The irregular twelve-hourly pressure fluctuations were much greater at the coast stations than at the ice-cap station, nearly twice as great in winter. This undoubtedly means that the air below 3 kilometres (10,000 feet) in the surrounding area is warmer in depressions than in anticyclones or ridges of high pressure. This has also been found to be usual in Iceland and North America. The British Isles and West Europe are an exceptional area in this respect, but even the same relation holds during very disturbed periods of weather.

The borings carried out in the ice 200 kilometres inland from the west station, at a height of 2480 metres, found stratified layers which could be identified with the precipitation of a summer or winter period. The average over five years is equivalent to an annual rainfall of about 30 inches, but there is a considerable variation between the years. The yearly evaporation would have to be added to give the true rainfall, but this cannot be large.

The two volumes are excellently printed and well illustrated, but one misses a good map showing all the observing stations. C. K. M. D.

PHYSICAL AND BIOLOGICAL GEOGRAPHY

WONDERS OF THE UNIVERSE: the world under the sea. By B. Webster Smith. *London: Hutchinson*, 1939. 9×6 *inches;* 230 *pages; illustrations and diagrams.* 7*s* 6*d*

Even the most striking results of modern oceanographical work are not widely known, and it is well to try to bridge the gap between the books which describe the shore and the shallow sea and the journals and reports which contain the newly won information about the open ocean. Mr. Webster Smith makes such

an attempt, offering the reader a simple account of some of the wider aspects of oceanography as well as a general survey of marine life.

It is therefore rather a pity that more than half the book should be devoted to animal descriptions such as can be found in many other elementary books. What is intended to be the main part of the book, the section which deals with the structure of the oceans and water circulation, is condensed to less than sixty pages. It is not always reliable; it gives a good idea of the scope of recent work, but the whole subject needs much more careful study than the author has been able to give it.

It is not true to say that water samples are valueless unless they are received at the temperature which they had when collected. Samples collected at depths greater than some 400 metres cannot be insulated from temperature changes for sufficient time to allow them to be hauled to the surface unchanged; the reversing water-bottle permits the temperature to be measured in situ and the subsequent changes must be allowed for. The differences in ocean level between various regions cannot be attributed to differences of gravitational force, so that the sea surface is pulled towards the higher parts of the continents. The real causes of such differences depend on the effect of the earth's rotation on currents—by which water tends to be heaped up on the right-hand side of a current in the northern hemisphere, and on the left-hand side in the southern hemisphere—and also on wind, differences of barometric height, and widespread density differences.

Many of the author's mistakes would have been avoided if he had been more careful to give chapter and verse for some of his statements. His book however contains much information, and is in many ways attractive. It is not quite up to date; echo-sounding has, for example, exploded the statement that the ocean floor displays on the whole a dreary and uniform expanse of immense plains which possess only the gentlest gradients. G. E. R. D.

ECONOMIC AND HISTORICAL GEOGRAPHY

CHRISTOPHER COLUMBUS. By SALVADOR DE MADARIAGA. *London: Hodder and Stoughton*, 1939. 9×6½ *inches;* xii+524 pages*; illustrations and maps.* 21*s*

The biographers of Columbus have several difficulties to overcome. Until his return from the first voyage there are hardly any first-hand documents extant, apart from some rather scanty material bearing upon his family and his early years in Genoa. Biographers are dependent for this early period upon his own statements and those of his friends and enemies, coloured by personal prejudices and a variety of motives, and written down at various periods after the events. A biography may therefore be planned to set out such facts as are known, without attempting to work them into a coherent whole, or the writer may form a general impression of Columbus' character and achievements as they were revealed after 1492, and then from the mass of secondary material reconstruct the early years, selecting, rejecting, and interpreting the statements in accordance with this impression. The former method will not perhaps produce a book with a wide appeal: the second may make an attractive and readable book, which however may be misleading unless the reader appreciates the basis upon which it has been constructed.

Señor de Madariaga has chosen the second plan. His thesis is that Columbus was of Spanish-Jewish stock, his family having been exiled to Genoa during the persecutions of the late fourteenth century. This connection enables him

to link Columbus with the Majorcan circle of cartographers, so that he is represented as an expert cosmographer. His early years are considered to have been spent as a sea captain and "corsair." Whether or not Columbus was a Jew, and the most that can be said is that this hypothesis if correct would explain some obscure passages in his writings, the evidence is by no means favourable to his scientific and nautical attainments. Señor de Madariaga himself seems to consider that on the whole Columbus based his project for a western voyage rather upon his interpretation of the prophet Esdras than upon contemporary scientific ideas, though much importance is attached to the influence of the so-called Toscanelli letter. This appears to be greatly exaggerated: apart from its doubtful authenticity, it contains nothing that was not then common knowledge, and certainly nothing that would have made the Portuguese king as anxious to recover it as de Madariaga suggests. If Columbus met with little support in Portugal, it is not unreasonable to assume that he could tell the Portuguese little that they did not already know, and that all their energies were engaged in another direction. The author tends indeed to underrate Portuguese achievements and to neglect the standard of navigational science at this period. Otherwise he would hardly have accepted the statement that Columbus had measured a degree, or maintained that he discovered terrestrial magnetism. It is also curious that if Columbus were experienced in affairs of the sea he should have ignored the Portuguese value for the length of a degree.

After the first voyage there is much first-hand material, and the necessity for dealing in "psychological imperatives" consequently declines. The author gives a very convincing picture of the difficulties that accompanied the early development of the first settlements, the varying policies of the Spanish sovereigns and Columbus towards the natives, and the personal rivalries among the Spanish leaders. But what seems more important, he presents Columbus' character, quite convincingly, in a way which seems at variance with his reconstruction of the latter's early years: his inability to handle subordinates, or to take decisive action, his extremely confused cosmographical notions, and above all his absorption in obscurely expressed religious ideas. The contradiction suggested here would be solved by regarding Columbus not primarily as a sailor and skilled cosmographer, but as an obstinate and persevering man, with an unshakable belief in himself, who, thrust into the seafaring life of the Peninsula, saw in the contemporary expansion westwards the opportunity of carving out a career to which he believed he had been divinely called. It must be emphasized however that no judgment on Columbus can be final. Señor de Madariaga has presented his own views very spiritedly and most readably, against a vivid background of contemporary Spanish history. G. R. C.

GENERAL

THE NATURE OF GEOGRAPHY: a critical survey of current thought in the light of the past. By RICHARD HARTSHORNE. (*Annals* of the Association of American Geographers, XXIX, Nos. 3 and 4. September, December 1939.) *Lancaster, Penn.: The Science Press Printing Co.*, 1939. $10\frac{1}{2} \times 8$ *inches;* vi + 482 *pages*

It is not often that a scientific journal devotes two whole numbers to a single communication. But the *Annals* of the Association of American Geographers have a long record of presidential addresses on questions of method and principle; and Dr. Richard Hartshorne's memoir brings into convenient shape the main recent controversies among geographers in the United States, and relates them to discussions elsewhere. It has taken final shape during a sojourn

in Central Europe, and Hartshorne makes no secret of his debt to the veteran Alfred Hettner, in many respects the most living force among German geographers, in the tradition of Humboldt and Richthofen. It is not the first time that a phase of German teaching in geography has found an American spokesman; Miss Semple became the prophet of Ratzel, Sauer of the "landscape" school, and W. M. Davis, earlier, of Peschel and Richthofen. This essay is none the worse for that, and one of its chief merits is the historical perspective in which successive and concurrent trends of thought are presented.

Essentially it consists of a dozen sections, each a stage in a continuous argument. Retrospect of the growth of geographical thinking, especially in Germany, and closer examination of some recent divergences of theory, leads to discussion of the various German uses of *Landschaft*, and American misuses of *landscape*, to denote the proper field of geographical inquiry; and then of the relations between geography and history, and the specific scope of "historical geography" as the application of geographical technique to the historian's problems within some past "period" of history, so far as its geographical conditions can be ascertained. Another mainly German controversy concerns the relevance, for the geographer, of phenomena not perceived by the senses; and this leads to the general question: what kinds of phenomena rank as "geographical facts," and what kinds of relations between them are of geographical concern? A long argument about the concept of the "region" as a "concrete unit object," an "organism," or characterized by "harmony" or "rhythm," illustrates by many examples the too common practice of first inventing and then worshipping an abstraction. Such analogies between geographical regions and biological individuals Hartshorne rightly thinks misleading: and other German terms—*Einheit*, *Ganzheit*, *Gestalt*—only need to be translated to be revealed as metaphors, neither helpful nor even significant. The concept of "region," nevertheless, has been, and still is, of value in geography; and Hartshorne's review of its history, and his own reformulation of it as a subjective aid to geographical inquiry, is the most constructive part of this essay. Recognizing the criterion of Herbertson, of "natural conditions as significant to man," and obviously influenced by Hettner's "genetic" system, he calls attention to recent American attempts to determine the "cultural unit" of the natural "landscape" under man's management, and to the technique of "ratio-maps" for interpreting the manifold "works of man" geographically. He doubts however whether a logical system of "specific" regions can be organized on the basis of any one principle. All this does not go far beyond what British geographers are practising; but it is useful to know what the transatlantic difficulties are, and encouraging to find that a "logical" solution of them supports our common sense.

The rest of the essay is a careful and sensible account of the twofold aims and procedure of geography, as a science "systematic" and "descriptive" at the same time and inevitably. The balance of interest in one aspect or the other has varied with the personalities of its exponents, and the progressive maturity of the study; but the scientific objective is the same "understanding of reality," and the true use of "systematic" universals is in drafting our descriptions of the unique.

A valuable feature of Hartshorne's memoir is the classified list of geographical work dealing with these general questions. If it includes few British items, it is because until quite recently they have attracted us less than the pedestrian task of writing and teaching geography as a field subject; and here our closer dependence on French work than on either German or American has simplified our practice, and perhaps also clarified our thinking; for a good deal of Hartshorne's thoughtful writing is devoted to the dissipation of bogeys. J. L. M.

GEOGRAPHY FOR TO-DAY. (Edited by L. DUDLEY STAMP and L. S. SUGGATE.) Book 4. Europe and British Isles. *London: Longmans, Green and Co.*, 1939. $7\frac{1}{2} \times 4\frac{1}{2}$ *inches;* xii+404 *pages; illustrations and maps.* 4*s*

EUROPE, THE BRITISH ISLES, AND THE WORLD. By C. C. CARTER and E. C. MARCHANT. (The world of man, Book IV.) *London: Christophers*, 1939. 8×5 *inches;* xx+300 *pages; illustrations and sketch-maps.* 3*s* 9*d*

THE WORLD: a general regional geography. By JASPER H. STEMBRIDGE. (The new Clarendon geographies.) *Oxford: Clarendon Press*, 1939. $7\frac{1}{2} \times 5$ *inches;* xii+532 *pages; illustrations, maps, and diagrams.* 6*s*

AFRICA, THE AMERICAS AND AUSTRALIA-NEW ZEALAND. By A. R. BARBOUR SIMPSON. xii, 142, 196, 60+vi *pages.* 4*s* 6*d.* Asia. By A. R. BARBOUR SIMPSON. x+208 *pages.* 2*s* 9*d. London: G. Bell and Sons*, 1939. $7\frac{1}{2} \times 5$ *inches; illustrations and maps*

The regional treatment of geography is now well established in text-books, so that they all present a certain similarity. There has however recently been a tendency to increase the scope of the subject-matter which is fitted into the regional scheme. All the books under review contain, for example, descriptions in varying detail of human activities and much historical and political material. This undoubtedly brings the subject into closer contact with reality, but it is perhaps asking too much of geography, as one author wishes, to deal with all "major human problems," and there is some danger that the fundamental considerations may be treated incidentally. There is considerable progress in the standard of illustration, more so than in that of the sketch-maps, many of which are now commonplace.

These books are approximately of the same standard, suitable for pupils preparing for the School Certificate. The volume of 'Geography for to-day' is clearly written and the interest well sustained. The text is free from statistical material and not overloaded with names, yet avoids vague statements. It contains more geological, and rather more historical material, as well as more detailed descriptions of farming practice and industrial processes, than the other volumes. The sketch-maps are not overcrowded with detail, and the illustrations are good and varied. A few points call for comment: enclosure in Britain began well before the eighteenth century and was not entirely initiated by rotation cropping; the derivation of Icknield Way from Iceni is at least doubtful; it is perhaps misleading to state that snow is rare in Devon and Cornwall; and a barometric reading of 28, rather than 29, inches, would be "very low" for the British Isles. The statement that over two thousand years ago Greece was "already suffering from its geographical character" is not expanded, the text actually describing the contribution of geography to the growth of Hellenic civilization. Considerable trouble has been taken with the geographical names: it is a pity therefore that the slip "Koninklijk der Nederland" was overlooked.

Messrs. Carter and Marchant's volume is agreeable to read, and is also not overloaded with lists of names and figures. Emphasis is placed upon the external and internal relations of the nations, and upon the growth and distribution of populations. The final chapter discusses the possibilities of a more even distribution of world population. While industrialization of the "newer" countries will no doubt tend in this direction, some reference might have been made to the development of the "empty spaces" where questions of capital expenditure, social amenities, labour supply, and marginal fluctuations are important. The statement that the British Isles have "rarely too much and equally rarely too little" rainfall requires modification. There are a few small slips: London is

not placed at the head of tidal, but of ocean, navigation; the Serbs do not use "old Gothic characters"; land reclaimed from the sea cannot be cleared of salt in a few months. The exercises to each chapter include test-maps to be memorized.

Mr. Stembridge treats both general and regional geography of the world in a compact volume. To cover adequately general geography in 96 pages is a very difficult task, and the author is limited largely to general statements which the teacher must amplify, *e.g.* the references to glacial action and river capture. The account of cyclonic disturbances requires to be brought up to date, and the implication that convectional rains are confined to equatorial regions corrected. The regional chapters, within the limits imposed, give an orderly summary of geographical factors, and the sketch-maps convey their points clearly. The significance of the distribution of wheat lands in England is rather obscured by the adoption of county areas as a basis.

In his preface Mr. Simpson comments upon the difficulty of discussing all the physical and biological processes to which the student of geography must pay attention, and defends his preference for economic and racial aspects. He treats his subject-matter effectively, with graphs to supplement the text, outlining the broad features of each continent and then describing the chief regions in greater detail. Some points in his treatment of North America require comment. The low January mean temperature of New York is due more to the prevalent west and north-west winds than to the cold coastal waters. A distinction should also be made beween the West Indian hurricanes and the tornadoes of the States. The share of man in the progress of soil erosion is not made clear, and it is perhaps this oversight that leads him to remark that the advance of the American farmer is due to his freedom "from the partly outworn heritage of traditional farming methods." It is surprising to read that the United States "regards itself as sovereign throughout those parts of the dual continent not already owned by a European Power." The statement that Vancouver discovered Vancouver Island is erroneous.

G. R. C.
L. C. W. B.

THE SPORT OF A LIFETIME. By EUGENE DE HORTHY. *London: Edward Arnold and Co.*, 1939. $9\frac{1}{2} \times 6\frac{1}{2}$ *inches;* 352 *pages; illustrations and map.* 21*s*

In reading this book it is not difficult to discern the sympathy of the author for the animal life amidst which he delights to live, in spite of the satisfaction he derives from slaying its most notable specimens. He writes graphically, with an eye to detail, and his book will be read with interest, although some would have liked more information about the home life of the boars and chamois of Transylvania, or of the tigers and mixed game of Indo-China. On the life and habits of the elephant of Kenya and Tanganyika Territory we are given useful comments, and there is sound criticism of shooting on insufficient evidence of *shamba* or plantation raiding. The author first visited Kenya in 1905 and again in 1937; he deplores, as must all who knew the colony in earlier days, the destruction of game which has taken place in the interim. The easy life enjoyed by the hunter nowadays compared with former times does not escape sarcastic remark, and the author cannot be accused of camouflaging his opinions with soothing words when dealing with the effect of the increase of white immigration on the native.

It is scarcely accurate to say that "science has not found a real remedy up to now" for sleeping sickness; if taken in time the majority of those infected recover. The abundant photographs are usually good, the index excellent, but the sketch-map of Kenya and adjacent territories might have been supple-

mented with outlines of the other countries visited. Several Swahili words are misspelt. J. P.

THE VOYAGE OF THE *CAP PILAR*. By ADRIAN SELIGMAN. *London: Hodder and Stoughton*, 1939. $9\frac{1}{2} \times 6$ *inches; 360 pages; illustrations and sketch-maps.* 18*s*

Mr. Seligman writes very well, and his voyage round the world as captain of the *Cap Pilar* gives him plenty of material. He may not give much new information about the oceans he crossed or the anchorages he reached, but most people will enjoy the book with its fine pictures and possibly learn a good deal.

The ship was a cod-fishing schooner from the Newfoundland Banks, bought and fitted out cheaply in St. Malo. The ship's company were young men who paid £100 towards the expenses of the voyage; their number varied between twenty and twenty-six, new recruits being signed on in South Africa, Australia, and New Zealand; some found attractive work in the Dominions, but most of them saw the voyage through; very few left just to go home. The author's very plucky wife accompanied him for most of the voyage, for the second of the two years nursing her baby daughter. Not more than three of the crew knew much about ships, and the rest served a pretty hard apprenticeship. The reader is not troubled with all the difficulties that beset an unmoneyed shipowner; but for those who might make a similar attempt there is enough to cause some hesitation, and then so much enthusiasm and good humour as to make them try it. The *Cap Pilar* had no auxiliary engine and spent long periods at sea; between South Africa and Sydney they averaged a good 6 knots, but even so they were out for seven weeks. All the ups and downs of life at sea are graphically described; there were no serious setbacks, and no one was any the worse for it.

There are good descriptions of the sailor ashore; Madeira was the first foreign port for many of them; Teneriffe was made somewhat tragic by the civil war; Rio was a pure holiday. The chapter on Tristan da Cunha emphasizes the quietness and sluggishness of the islanders and the unconventionality of the missionary. South Africa was nearly attractive enough to keep them all, but they went on to enjoy Sydney and Auckland, and to reach their main objective: the palm trees and coral of the South Sea Islands. They visited the Gambier Islands, the Marquesas group, and the Tuamotu Islands. The notes on these islands are well worth reading. Lastly they saw Callao, the Galapagos Islands, the Canal Zone, Jamaica, and New York, all of which are much more fun seen from a vessel lying in the docks than they are from ordinary ships and hotels.

G. E. R. D.

THE MONTHLY RECORD

THE COLD WINTER OF 1939–40

The past winter was very cold all over Europe, but no information is yet available from the Continent as to how the intensity of the frost and the ice conditions in the Baltic, Black Sea, Danube, and other rivers compared with those of 1928–29, which in eastern Europe was officially described as the coldest for a hundred years. For the British Isles however abundant data are at hand for the large number of meteorological stations given in the *Monthly Weather Reports* of the Meteorological Office. The frost lasted with but brief minor intermissions from the middle of December till the middle of February, reaching its most intense phase in the third week of January. The isothermal chart as reduced to sea-level shows that over a large inland area in England and a smaller one in Scotland the mean day and night temperature for the entire month of January 1940 was between 28° and 30° F. In London the mean temperature of 31° at Kew, 30° at Greenwich, and 29° at Hampstead indicates that the month was the coldest January since 1838, but only the coldest calendar month since February 1895. Both in that month and in December 1890 the mean temperature was a degree or two lower than in January 1940, and the tidal portion of the Thames was heavily encumbered with ice-floes.

On or about 20 January 1940 readings below zero Fahr. in the screen were recorded at many places in Great Britain, the extreme figures being −10° F. (42° of frost) at Rhayader and −7° at Llandrindod Wells in Central Wales, −6° at Bodiam in Sussex and Ambleside in Westmorland, and −5° at Dalwhinnie in Inverness-shire. It is always found that very low night temperatures occur inland at places where the local configuration favours the accumulation of cold air in hollows, and that only extremely insular locations on the Atlantic seaboard never experience really severe frost. In the past season the figures for Rhayader and Llandrindod Wells, supported by other sub-zero readings in Wales and by a reading as low as +2° at Cullompton in Devon, show how close to the Atlantic coast the extreme cold was felt; in fact it was only in the Scilly Isles that the temperature did not drop lower than 25°. In the south-east of England extreme cold occurred actually on the coast itself, as shown by the minimum of −3° at Whitstable-on-Sea, a figure supported by −4° at Canterbury. In these conditions it seems likely that the sea was to some extent frozen off the Kent coast. The coldest stations as regards the mean minimum temperature in January were Rickmansworth, Herts, with 17° and Thetford in the sandy Norfolk breck county with 18°, though at neither place did the extreme minimum fall below zero.

Although the season relatively to recent winters was perhaps less remarkable for snow than for frost, there occurred on the night of January 27 over the greater part of Great Britain a fall of dry drifting snow which was extremely heavy in the north of England. The general depth of snow in parts of Yorkshire, Derbyshire, Cheshire, and Lancashire was about 3 feet and disorganization of communications was very serious. The vast accumulations on the Lancashire coastal plain, a district usually free from heavy snowfalls, may in some measure have been augmented by mass drifting from the Pennine uplands, which were reported in places to have been swept bare by the east wind. The meteorological circumstances of this great snowstorm are rendered the more interesting from the fact that at the same time a severe ice storm devastated a wide tract of western and southern England to within a comparatively short distance of London, causing

immense damage to wires and trees, and mortality among birds. The phenomenon was due to an influx of warmer air at higher levels leading to the condensation of mist, drizzle, and rain in a super-cooled state so that the water instantly froze on touching the ground (*Meteorological Magazine*, March 1940).

January was an exceptionally sunny month for the time of year with many days of blue sky and beautiful hoar and rime effects; but the combination of brightness with great cold is easy enough in those latitudes where the winter sunshine is so feeble.

It may be noted that though the hard weather of 1939–40 happened to fall more or less symmetrically around what is normally the coldest period of the year, this is not an invariable or even usual experience. In this connection it is worth while pointing out that the lowest air temperature ever recorded in the British Isles, namely −23° F. (55° of frost) at Blackadder in Berwickshire, occurred as early as the 5th of the rigorous December of 1879. L. C. W. B.

ECONOMIC DEVELOPMENT OF THE SOVIET UNION

In a report published in the *International Labour Review* (February 1940), Mr. A. Abramson summarizes from the official literature the economic development of the Soviet Union since 1932. The treatment is largely statistical, but some geographical trends are emphasized. The population in 1939 was returned as 170·5 million, of which one-third was urban, compared with a population of 147 million in 1926, 18 per cent. urban. This doubling of the urban population is reflected in the doubling of the population of Moscow, Leningrad, and other large cities. The administrative, professional, and technical classes were estimated at 9·6 million.

The 250,000 collective farms are responsible for practically the whole of the agricultural output. The area under cereals has increased by 23 per cent. since 1932, and the centre of grain production is shifting away from the Ukraine towards the north and east. Production in South Russia has suffered from droughts, and it is proposed to alleviate their effect by building hydro-electric works at Kuibishev (Samara) and elsewhere. The increase in cotton and oil-bearing plants was proportionately larger. The number of horses and sheep is lower than in 1916, though that of cattle and pigs is higher. It is stated that the size of permitted holdings of individuals on collective farms show a tendency to increase, and that steps have been taken to prevent this. The industrial output is stated to have had an annual increase of 17 per cent. from 1932 to 1937. The planned increase in consumer goods was not achieved, and the concentration on producer goods is to continue. No factories are to be built in the existing large centres, and industries are to be established nearer sources of raw material and consuming centres. Increased attention is to be given to the eastern areas: a textile centre for Central Asian cotton, and coal mines and cement factories for the Far East, are planned. The increases in electrical energy, coal, and petroleum (37 per cent. increase 1932–37) did not reach those estimated. Mines are to be developed in the Moscow area and the Urals to relieve the pressure on the Donets basin. The best results were obtained in the iron, steel, and engineering trades, though the output of locomotives and rails was below the allotted figure.

The position in the timber industry was the least favourable, and it is proposed to develop the resources of the north European and Ural regions to avoid transport from Siberia. The output of cotton and woollen goods also failed to reach the standard set, not from lack of raw material but from the inadequacy of the spinning mills. The output of foodstuffs and sugar beet was satisfactory.

The general position appears to be that progress in the production of raw

materials and in the heavy industries was on the whole satisfactory, though the latter suffered from concentration in a few areas. The crux of the situation lies in transport; the strain on the railways is shown by the following figures of the goods handled: railways 90 per cent., inland waterways 8, road 2; hence the proposals for further industrial decentralization, development of the Far East, and the restriction of the scale of new undertakings.

NOTE ON ASCENT OF THE HUASCARAN PEAKS

In his paper on the Central Andes of Peru, published in the *Journal* for April 1940, Dr. Harrison refers to Doctor Hans Kinzl's map of the Huascaran Range "around its highest peak, Huascaran, which his party scaled for the first time in 1939." Colonel E. L. Strutt has kindly reminded us that there are two peaks of Huascaran, of which the southern and higher, 22,182 feet, was first climbed by a party of five German mountaineers in 1932: see *Alpine Journal*, XLV, 38–41, and Borchers' 'Die Weisse Kordillere' with the good 1/100,000 map by Lukas, Hein, and Kinzl. Doctor Hans Kinzl is an accomplished and widely travelled geographer, but took no part in the ascents of 1932. With his mountaineering colleagues he has continued work in the range, and in 1939 his party climbed Huascaran, north peak, 21,812 feet. It seems that the German party do not accept Miss Annie Peck's claim to have made the first ascent of that peak in 1908 with two Swiss guides. Colonel Strutt writes that he asked Taugwalder in 1928 about Huascaran, and the latter had no doubt that Miss Peck, G. Zumtaugwalder, and himself had reached the summit of the north peak in 1908.

ECONOMIC DEVELOPMENT OF CHILE

In a thesis entitled 'Mittelchile als Wirtschaftraum' (Leipzig, 1939) Dr. Böttger describes the present stage of economic development in central Chile, taking the geographical factors into due account. He is not concerned with Chile north of Valparaiso or south of the Bio Bio. Sixty per cent. of the population of the republic is however concentrated in the central valley which, lying at the foot of the Andes yet cut off from the sea by the Coast Range, is almost continental in character. The population density is high for South America; so also is the agricultural yield. The prospects of improving the latter and the future of nascent Chilian industry are the author's main concern: Chile, having suffered during the last war and in the crisis 1929–33 from the decline of her principal exports, copper and nitrate, has made some attempt to develop local industries; and these steps towards autarky Dr. Böttger views with sympathy, though recognizing their limited possibilities. Chile is one of few South American countries possessing coal, though it will not serve for melting the ore mined locally; her textile industry is advancing rapidly; the woods of the south supply her with timber; she can export meat and fruit, and some wheat and barley. In general however these exports are likely to remain modest; they are not encouraged by poor communications and lack of good harbours. Unless there is an increase in population the internal market is limited: in certain home protected industries like shoe manufacture saturation point has already been reached. The main problem as Dr. Böttger sees it lies in increasing the four and a half million population: any other means of increasing purchasing power would lead to a rise in wages that would diminish Chile's precarious exports. There exists the modest possibility of extending the internal market by intensifying cultivation in the central valley, partly through irrigation, partly through the division of large estates and the formation of a class of small-holders. This reform, hardly advanced by the Six Year Plan of 1928 and the Five Year Plan of 1936, and the development of industry, necessitate the strict government

control practised in the author's own country. His summary is clearly written; the information is up to date and its origin clearly indicated; and the text is provided with numerous sketch-maps.

THE CAYMAN ISLANDS

We are indebted to Mr. C. E. Hamshere, a Fellow resident in Jamaica, for calling our attention to an error in Major Douglas' article on the Cayman Islands, in the *Journal* for February last, on p. 126. Sir Thomas Modyford, Governor of Jamaica, visited the islands during his term of office 1664–1671. The islands were colonized and proclaimed a British possession in 1734. But a description of the islands published by the Cayman Islands Yacht Club tells of an historical pageant played by the islanders, of which one scene depicts a visit of Governor Modyford in the eighteenth century who formally takes possession in the name of His Britannic Majesty. Major Douglas regrets that he was misled by this passage into writing that in 1734 the islands were colonized and proclaimed British by Modyford. He asks us to correct also a mistake on p. 128: the hurricane was in 1932, not 1933.

SOURCES OF FATS AND VEGETABLE OILS

The world supply of fats and vegetable oils and the development of the market is examined by H. Böker in the *International Review of Agriculture*, June 1939. During the nineteenth century, Western Europe, despite increases in its produce of butter and lard and oil-seeds, became a world market for these products, both for food and industrial purposes. In the 'eighties, the centre of oil-seed production shifted from western to east and south-east Europe, and particularly to overseas areas. The United States' production of cotton seed rose rapidly; used chiefly for manufacturing a lard compound, it released great quantities of animal lard for export. The output of copra from the Dutch East Indies, of ground nuts from British India, and, later, cotton seed from China also increased. As a result of this competition, agriculture in Western Europe shifted to the production of butter and live stock, based upon root crops and fodder. The increase in population and the rise in the standard of living in the opening years of this century strained local resources of animal fats, resulting in the rising import of butter from Denmark, Holland, and the developing areas in New Zealand and Australia. This situation, assisted by the decline of United States' exports of lard, offered an opening for the margarine industry, utilizing new oil plants such as the soya bean. Vegetable oils were used to an increasing extent for food and less for industrial purposes. The import surplus of oil yielding raw materials in the United Kingdom thus rose from about 770,000 metric tons in 1909 to 1·5 million tons in 1913, and in Germany the proportional increase was greater. After 1918, these tendencies became more pronounced, and the consumption of these products for food increased, owing to technical improvements, *e.g.* in the treatment of ground-nut and soya-bean oil, the growth of tropical supplies, and the use of whale oil for margarine. Thus in 1929 the production of margarine in Europe was 1·1 million tons, against a butter production, excluding the U.S.S.R., of 1·4 million tons. Indirectly also the value of these raw materials for food production increased, for the agricultural industries became largely dependent upon great supplies of oilcake. In 1936, the United Kingdom was using 1·5 and Germany 1·2 million tons. The United States, Japan, and Italy also became large consumers. After the economic crisis of 1929, most countries endeavoured to limit their dependence upon these imported supplies, though with considerable difficulty. Thus by 1937 the world production of vegetable oils (11·2 million tons) was almost twice that of the 1909–13 average. Asia contributes about 43 and Africa 13 per cent.

of this total, the chief exporters being the Netherlands Indies, Argentina, Manchukuo, and Nigeria. The chief importing countries were the United States, Germany, the United Kingdom, and France. Similarly the output of butter has expanded in recent decades, the European figures showing a particular increase, from 1·1 to 1·5 million tons between 1925 and 1936. Denmark, closely followed by New Zealand, has been the leading exporter. Britain's share of the world imports of butter was no less than 80 per cent. in the years 1934–36, Germany taking about 10 per cent. in 1934, but the proportion increasing in later years. As regards whale oil, largely used for margarine, for the years 1934–36, Germany took about 40 per cent. of the total production, and the United Kingdom about 30 per cent. Of the total consumption of oils and fats in Germany, imports represented 45 per cent. in 1936. Owing to the large imports of butter, the percentage for the United Kingdom was much higher. The consumption of butter and margarine per head in Germany (1936) was 8·5 and 6·6 kg., in the United Kingdom 11·3 and 3·9 kg. The proportion of animal fats and oils in margarine has decreased continually and is now small, 1·2 per cent. in Germany, and about 6 per cent. in the United Kingdom. The proportion of whale oil has correspondingly increased; 28 per cent. in Germany, and 41 per cent. in the United Kingdom.

OBITUARY

JOHN F. BADDELEY

Historical-geographical research has suffered a serious loss through the death of our Medallist, John F. Baddeley, which took place at Oxford on February 16 last, at the age of eighty-five. In spite of his age and, latterly, of indifferent health, he had persevered in the studies on the history of the Caucasus, which he had made specially his own, and all who knew the value of his previous work in that and cognate fields had anxiously awaited a new monumental work comparable to that which gained him the Victoria Medal of this Society in 1922.

Born in July 1854, just at the outbreak of the Crimean War, Baddeley was second son of Captain (afterwards Lieut.-Colonel) J. F. L. Baddeley, who went to the war as Adjutant to Colonel N. T. Lake, R.A., and thus what was to prove a life-long connection with Russia began actually at his birth. It was also fostered by his mother's friendship with Russians she had met in Paris, which led to a close intimacy with Count Schouvaloff, when the latter became Russian Ambassador in London in 1874. John Baddeley had been educated at Wellington College, where he had been keen both at books and games, and after leaving school had had a somewhat rough time in South America. His first personal knowledge of Russia resulted from Schouvaloff's invitation to join him when paying a flying visit there in 1879. During seven months' stay he travelled extensively, and besides enjoying some sport, picked up a good working knowledge of Russian, both written and spoken. The experience so gained procured for him, before the end of the year, the post of special correspondent of the *Standard* in Russia, which he held for ten years; his book, 'Russia in the eighties,' not published till 1921, is valuable for the sidelights it throws on now half-forgotten happenings. It is also interesting as a personal narrative of adventure and sport. In 1888 he made acquaintance with the Caucasus during the Tsar's visit, and so started a special interest in that part of the world which in time led to the production of his first important historical work, 'The Russian conquest of the Caucasus' (1908). It embodied the results of pains-

taking research, for which his intimate knowledge of the relevant Russian literature gave him special opportunities.

Another, widely separated, part of the Russian Empire which aroused his special interest was the far north-east: the region of the Amur and other parts of eastern Siberia, in which he also travelled extensively, sometimes over very little known ground. Here again the early doings of the Russians appealed strongly to his historical sense, and he became specially interested in various important Russian narratives of travel previously neglected, which he decided to publish in English translations. With characteristic thoroughness Baddeley extended his survey over a much wider field, carrying out minute researches on all that could elucidate the central theme, and the result was the publication, in 1919, of 'Russia, Mongolia, China,' which threw a flood of new light on the early Russian efforts to open up intercourse with the rulers to the south, at the same time giving a vivid insight into the general historical geography of northern Asia. Produced in sumptuous style, with many reproductions of early maps (some previously almost unknown), it appeals to all lovers of fine books, even apart from its intrinsic value, which gives it a unique place in the literature of northern Asia.

It was while engaged in his studies for this work that Baddeley's attention was called to the big Chinese map of the world by Matteo Ricci, of which a copy is preserved in the Society's Collection, though its importance had been somewhat missed. Baddeley devoted some time to a study of the map's inception and history, giving the results in the *Journal* for October 1917. His article supplied a valuable preliminary treatment, since extended by competent Chinese scholars, both in England and abroad.

Returning to his first love, the Caucasus, Baddeley planned another big work on the history of that region from the earliest times, and as usual his methods were nothing if not thorough, though this necessarily delayed the completion of the book. It is hoped however that it may be published quite soon.

Baddeley was of a singularly modest and retiring nature. He never put himself forward as an explorer, in spite of the extent of imperfectly known ground he had covered. A man of great personal charm, he was regarded with feelings of real affection by his more intimate friends. Among his other gifts he developed somewhat late in life a delicate skill in flower-painting, and he was putting his artistic talent to good use for the illustrations to his latest work. Applied to the map of a mountain region like the Caucasus the results were surprisingly vivid and instructive. His valuable collection of Russian geographical and historical books was given to the London Library (and a few also to our own). E. H.

MEETINGS: SESSION 1939–40

Sixteenth Meeting, 8 April 1940. The President in the Chair

Elections: Eric Thomas Caparn, O.B.E., M.C., A.M.I.E.E.; Miss Kathleen M. Damon, M.R.S.T.; Theodore Ernest Day; Lady Hoyle; Mrs. Ellen Wood King; Lieut. H. O. Mateer, R.A.; Sydney R. Montague; Gordon Rae; Miss Helen Rolleston; Colonel James Baldwin-Webb, T.D., D.L., M.P.

Paper: Primitive tribes in Madagascar. By Mrs. O. Murray Chapman

Seventeenth Meeting, 15 April 1940. Mr. Leonard Brooks, Vice-President, in the Chair

Paper: Coral islands and mangroves in Jamaica. By Mr. J. A. Steers, Dr. V. J. Chapman, Mr. J. Colman, and Mr. J. A. Lofthouse

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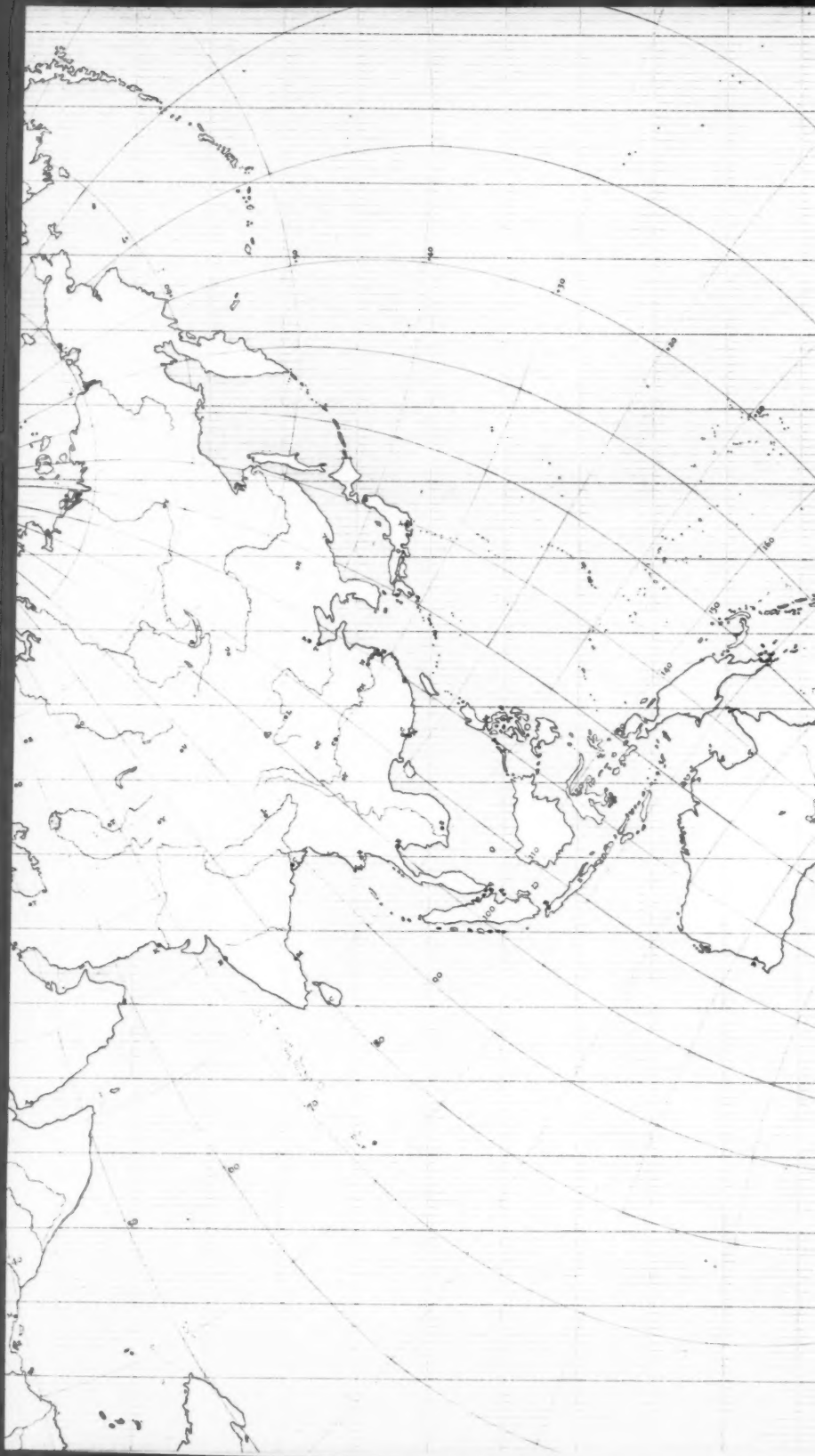

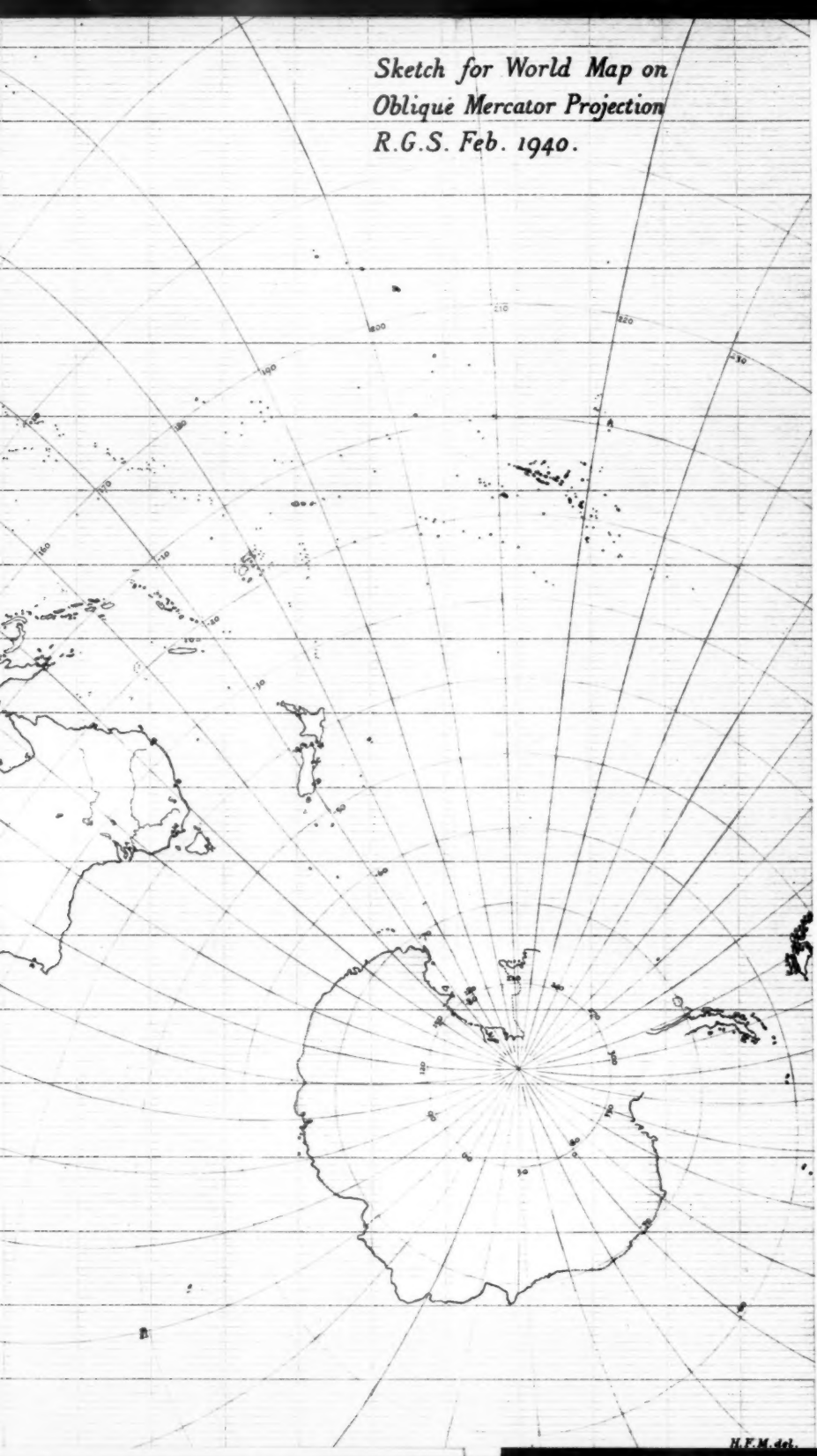
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R.G.S. Feb. 1940.
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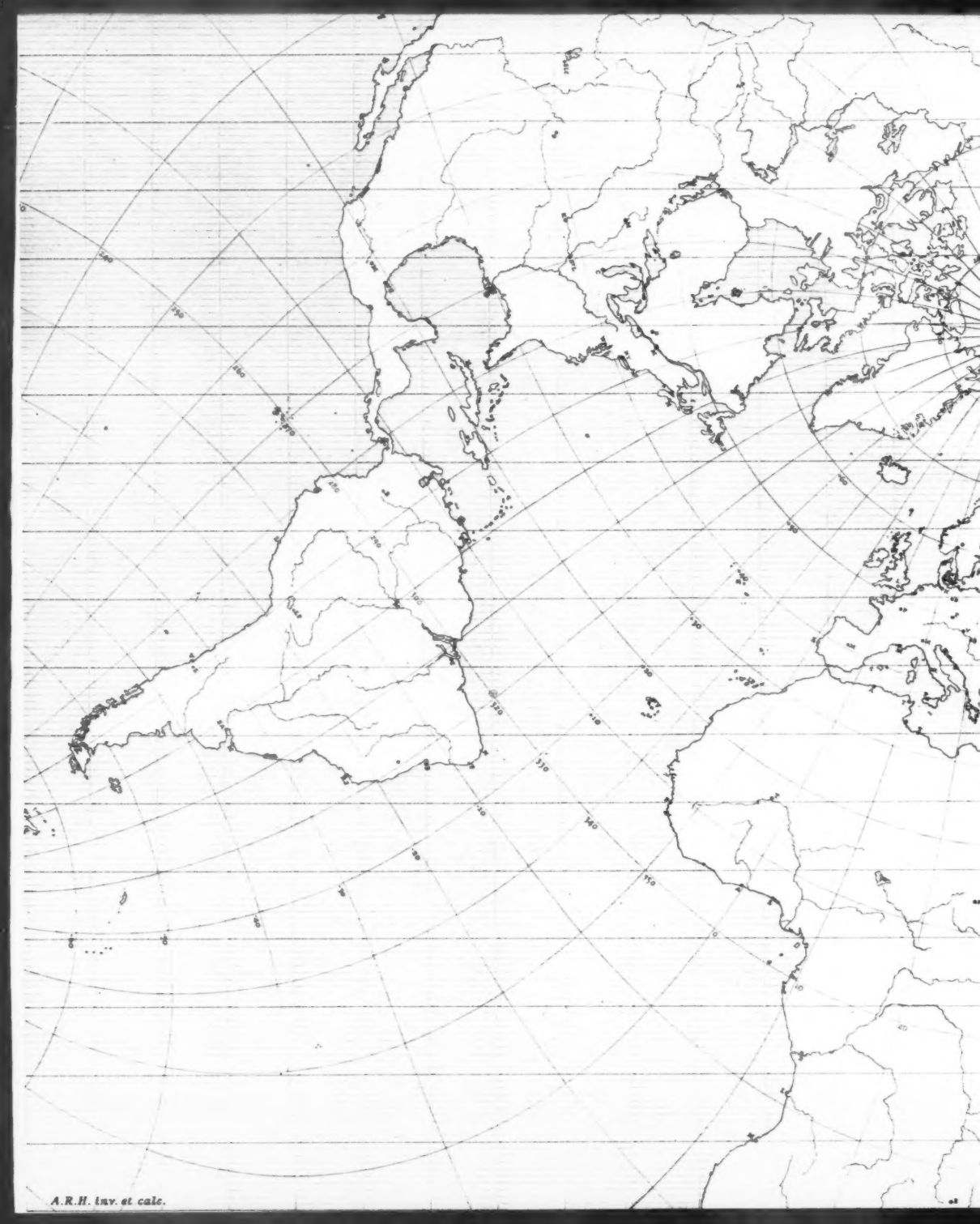

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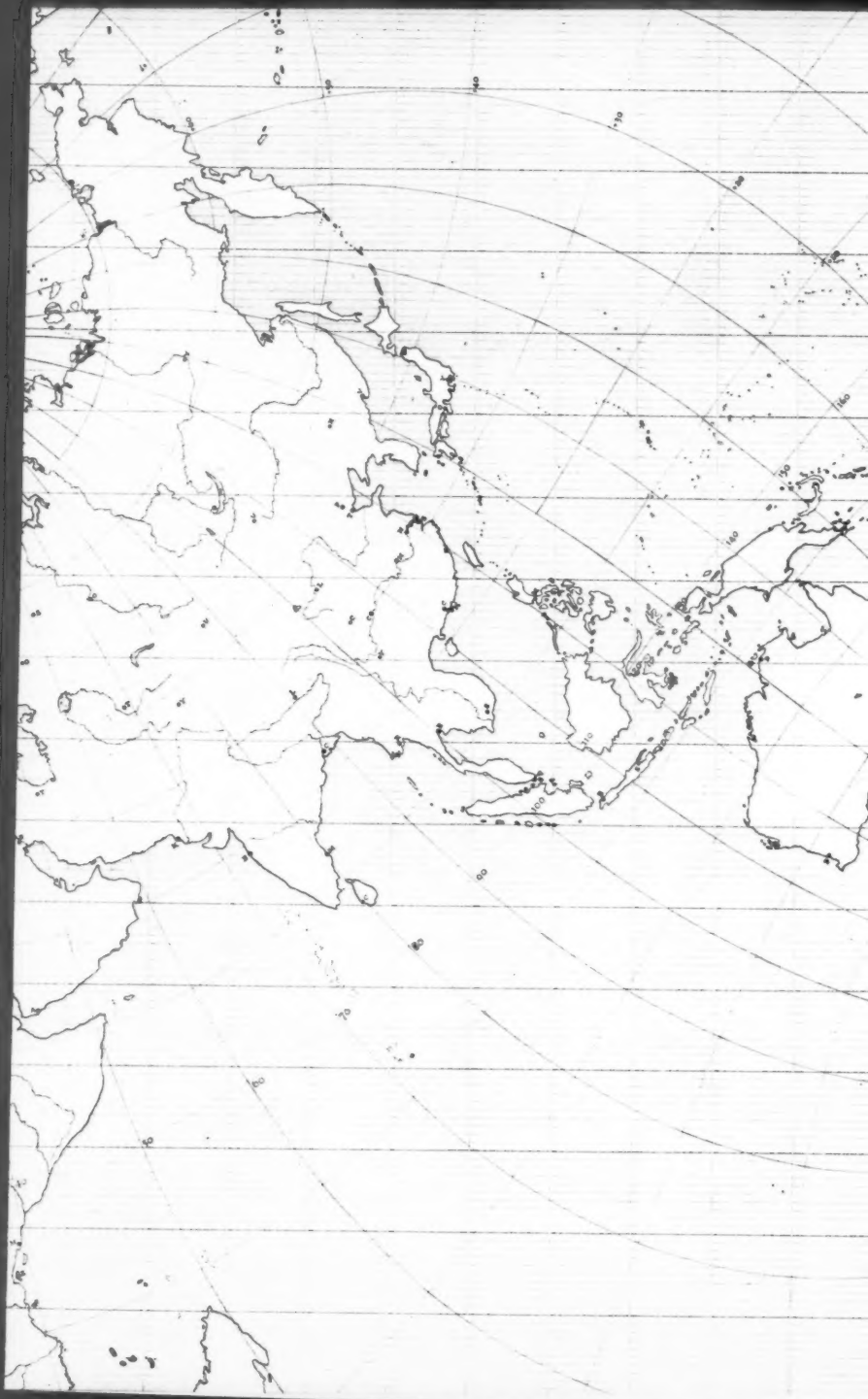

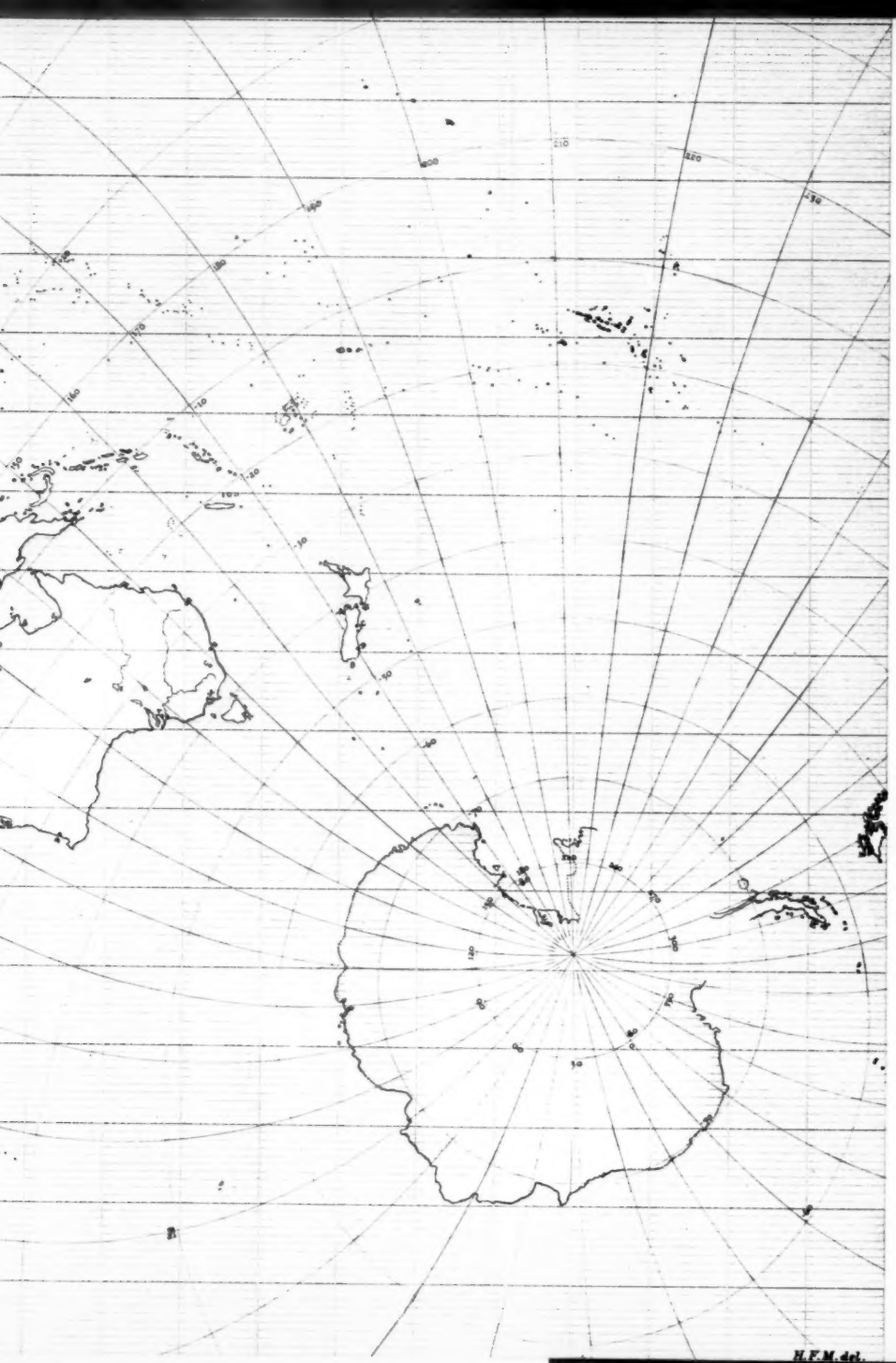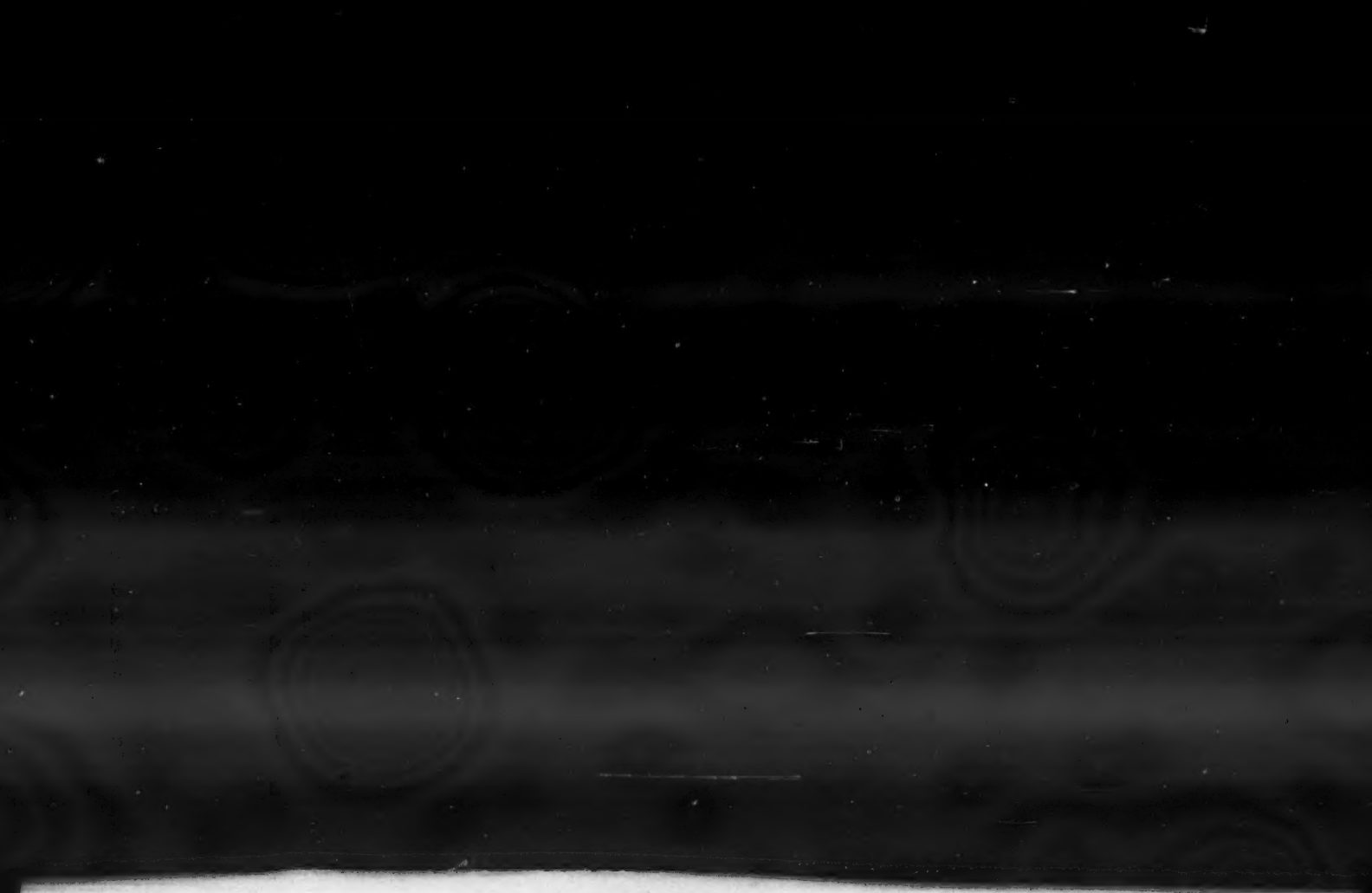
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